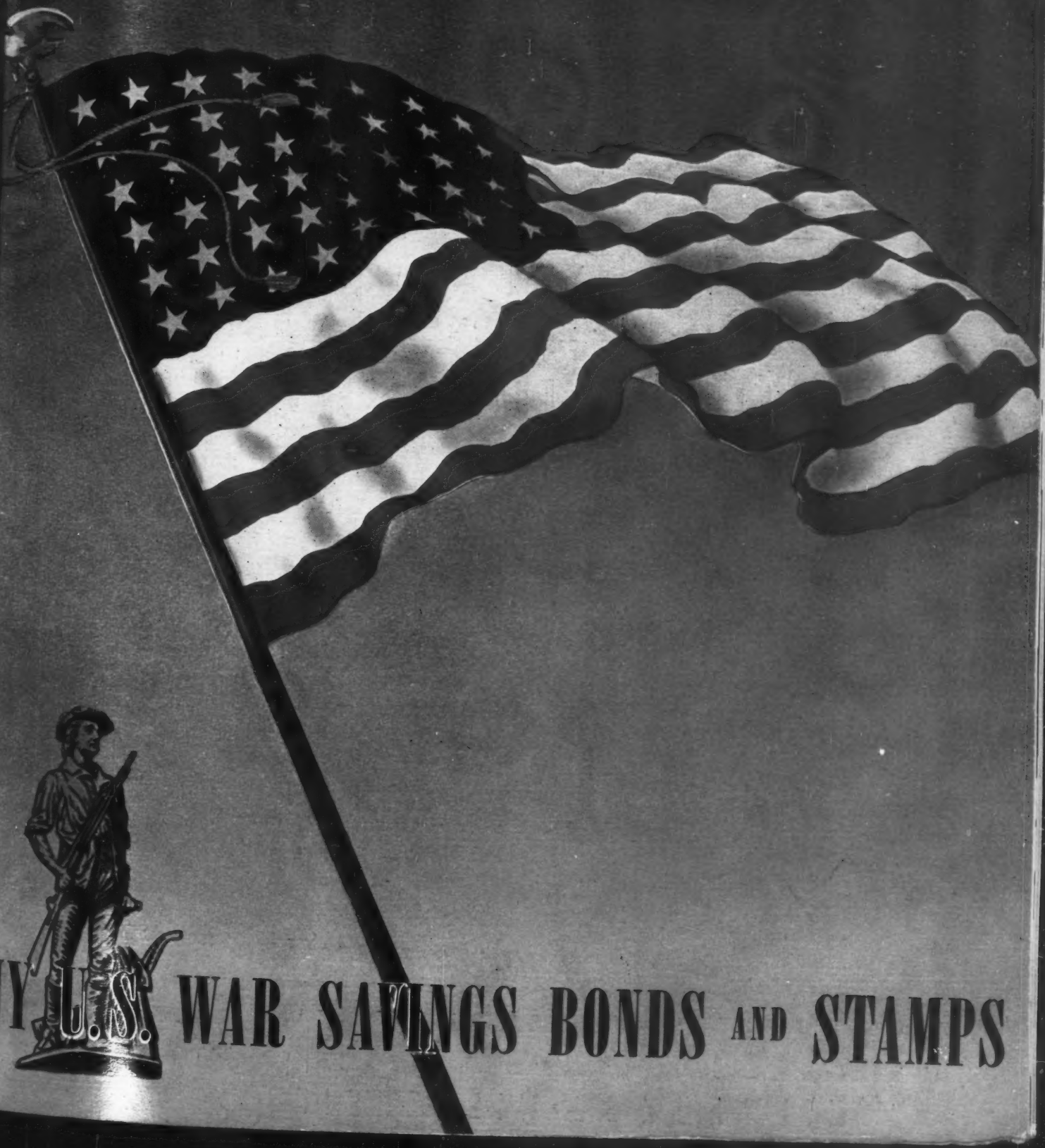
MACHINE DESIGN

July 1942



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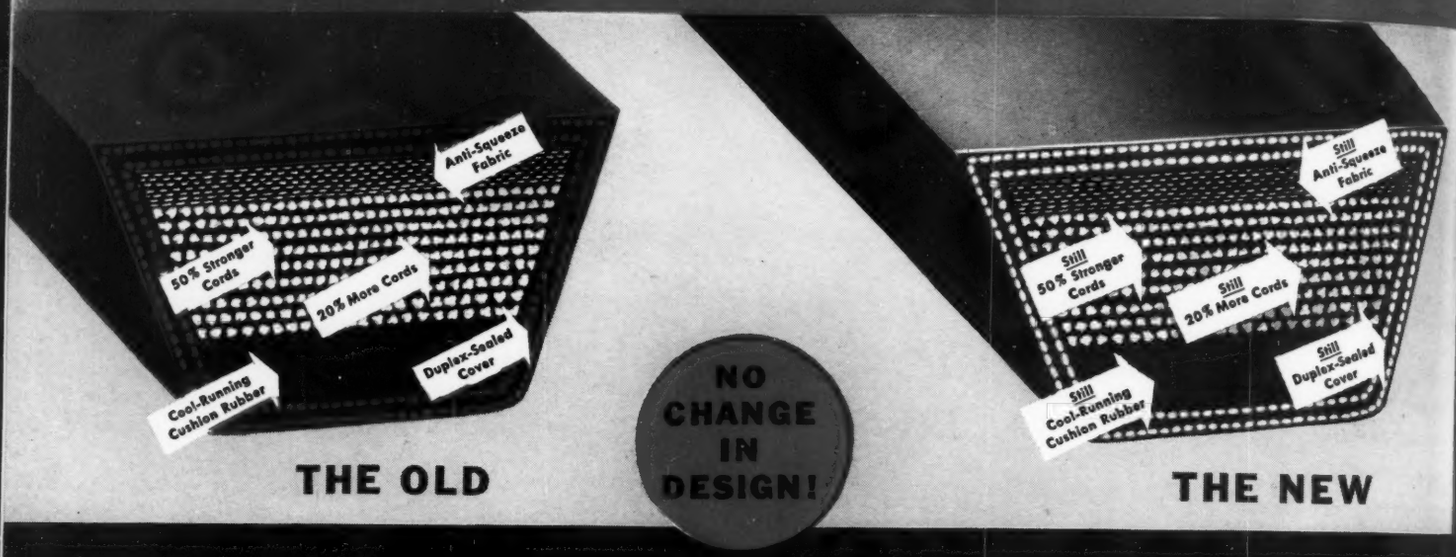

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2. The 20% more cords that help give Texrope Super-7 V-Belts their extra "muscle".
3. The increased life provided by Texrope's shock-absorbing, cool-running rubber cushion.
4. The extra protection against grit, grease and dampness of the duplex-sealed cover. The *only* thing changed in cover design is the color!

NO ONE SAID we *had* to do it . . . but by sacrificing the red surface color identified with Texrope* Super-7 V-Belts, more rubber could be made available for Uncle Sam's new and special war-time needs.

So Allis-Chalmers did what *you* would have done . . . switched the famous "Red Belt" to a war-time black.

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To step up the war-time efficiency of *your* power transmission, get the advice—and help—of your Texrope dealer or the Allis-Chalmers district office near you. Or write Allis-Chalmers, Milwaukee, Wisconsin. A-1517

*Trade mark registered U. S. Patent Office. Texrope Super-7 Belts are the result of the co-operative research and design genius of *two* great companies — Allis-Chalmers and B. F. Goodrich — and are sold exclusively by Allis-Chalmers.

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WE WORK FOR VICTORY — WE PLAN FOR PEACE

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Volume 14 JULY, 1942 Number 7

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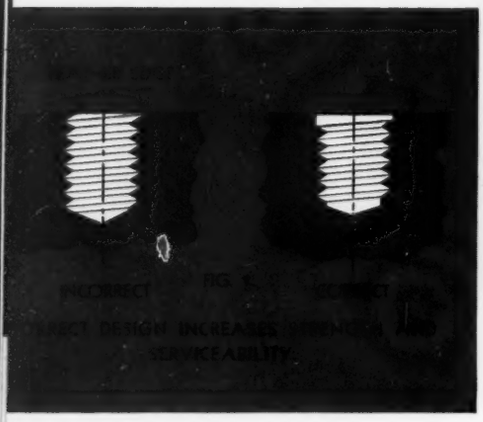
Designing Molded Plastics Parts:

from the engineering files of One Plastics Avenue

For applications where integral threads are required in molded plastics parts, design specifications should be based on these points:

1. Standard threads are used in plastics parts.
2. Start molded threads at least 1/32 in. from end of face perpendicular to axis of thread to eliminate feathering. (See Fig. 1.)
3. Threads should terminate abruptly in a shoulder of major diameter. Do not design to terminate in feather edge.
4. Countersink threaded holes to facilitate entrance and withdrawal of machine tap.
5. Mold threads in blind holes where space is limited. Thin walls tend to crack when tapped.
6. Make pitch as large as possible to allow greater tolerance and provide sufficient engagement of threads for strength.
7. Threads of large diameter (5/16 in. or more) are generally molded; smaller diameter threads are molded as smooth holes and tapped.



TYPICAL APPLICATION Used in an application requiring little stress on threads and infrequent removal of cover, this gage case of large diameter is best designed with integral molded threads.

SPECIAL CONSIDERATIONS Close tolerances required to maintain proper thread engagement of parts having more than 32 threads per inch make production difficult and costly.
For economy, molded threads should be avoided whenever possible.
A special round profile thread is used when plastics part engages glass threads.
Where frequent disassembly is necessary use threaded metal inserts.
Provide an adequate number of threads if tight seal is required.
Because of shrinkage subsequent to molding, long-molded threads will not fit standard metal threads but will fit corresponding molded threads.
Threads are more difficult to mold in high impact materials than in general purpose grades.

ADDITIONAL FACTS Many factors influence selection of proper methods for producing threads in molded parts. G-E Plastics Department engineers consider practicability, design of mold, costs of manufacture, alternative methods, suitability to desired application, etc., for all threaded parts. This complete engineering service is at your disposal.

MANUFACTURING DATA Threads may be (1) molded integral to part, (2) tapped after molding, or (3) molded in two sections, flash and parting lines being removed with a sizing die after molding.

Molded threads range from 67 per cent to 75 per cent of thread. In small, tapped holes no fit closer than Class II nor more than 68 per cent thread is possible.

Make provision for unscrewing part from mold pin or cavity. On tapped threads do not specify more than 1/8 in. diameter as tap chatter will chip part.

ONE PLASTICS AVENUE at Pittsfield, Massachusetts, is the headquarters for five plants of the Plastics Department of the General Electric Company. It signifies the location of complete plastics facilities for development, material manufacture, designing, engineering, moldmaking, molding and laminating.

REPRINTS of this advertisement may be obtained by writing Section D-7, General Electric, Plastics Dept., Pittsfield, Mass.

PLASTICS DEPARTMENT

GENERAL ELECTRIC

Itemized Index

Classified for Convenience when Studying Specific Design Problems

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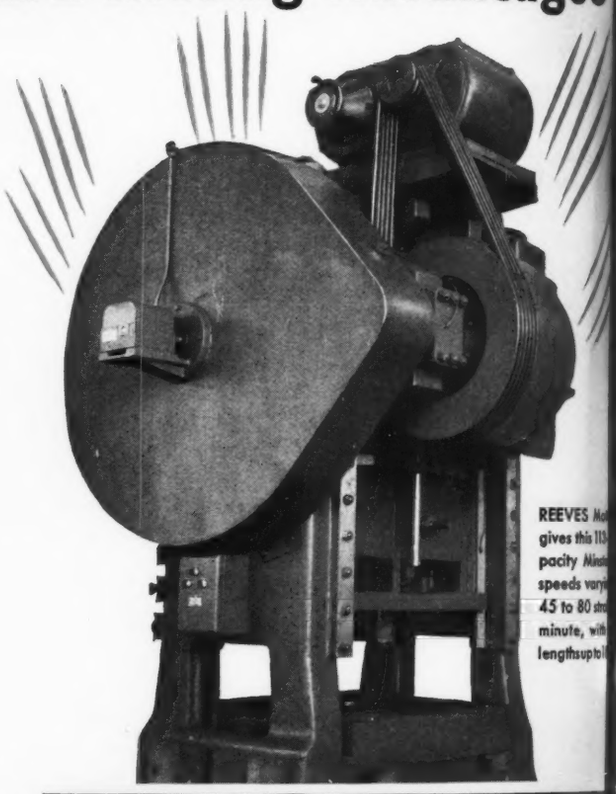
3 **OPERATING PRINCIPLE PROVED** in 210,000 installations, including use as standard equipment by builders of 1,440 different makes of machines.

4 **NATION-WIDE ENGINEERING SERVICE,** consisting of seasoned speed control engineers located in 36 leading industrial centers to help you choose the best unit and apply it correctly.



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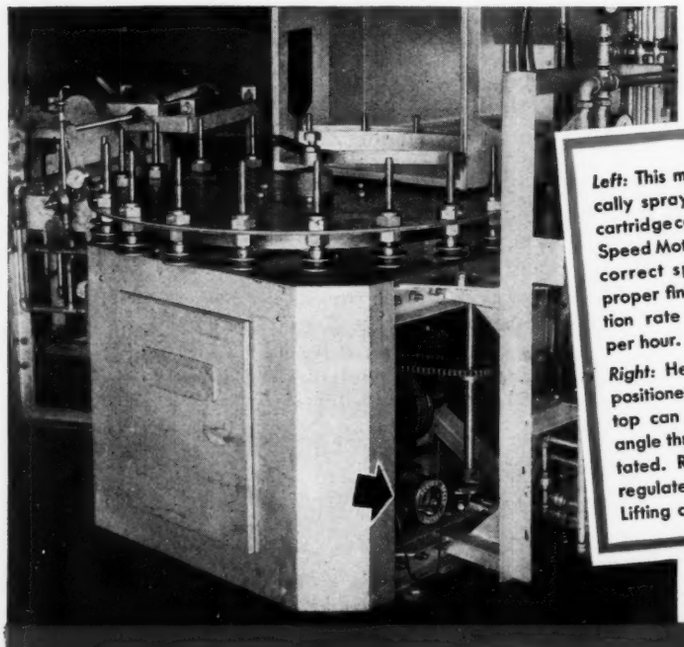
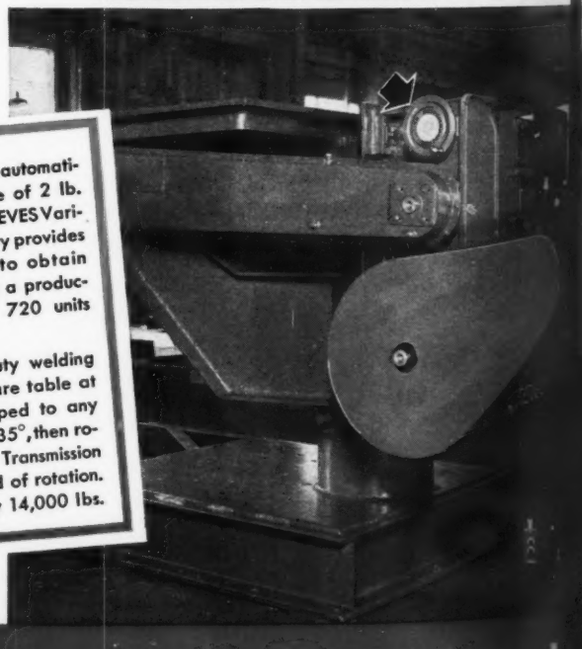


Left: This machine automatically sprays inside of 2 lb. cartridge cases. REEVES Vari-Speed Motor Pulley provides correct speeds to obtain proper finish and a production rate up to 720 units per hour.

Right: Heavy duty welding positioner. Square table at top can be tipped to any angle through 135°, then rotated. REEVES Transmission regulates speed of rotation. Lifting capacity 14,000 lbs.



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OUR AID ON THESE 4 POINTS WILL HELP US PRODUCE AND DELIVER MORE MOTORS

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Your choice of G-E Tri-Clad motors will give you *extra protection* against (1) physical damage, (2) electrical breakdown, (3) operating wear.

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance

SPECIFY TRI-CLAD MOTORS

GENERAL ELECTRIC

Use standard, open, sleeve-bearing motors whenever possible

The standard Tri-Clad motor, though classed as an "open" motor, is so well protected that it gives good service on many jobs where special motors often were recommended.

Sleeve-bearing motors often can be supplied more readily than ball-bearing types because of the present demand for ball bearings on other war equipment. Use ball-bearing motors only where load or mounting conditions require them.

Special end shields and other modifications may result in delay for you and others.

Consider the use of standard or multispeed a-c motors in place of d-c motors wherever this alternative is possible.

order motors early . . . giving complete specifications

Place motor orders when you order the machines they are to drive.

If you are planning motor drives for conveyors or other equipment for new plants, place the orders as soon as design work indicates the motor requirements.

Avoid delay and mix-ups by giving complete specifications, preferably on an order form which your G-E motor representative can supply.

give complete priority information, properly endorsed

The filling of many motor orders is delayed because of incomplete priority information. If in doubt about details, call the nearest G-E office.

When placing orders for motors, be sure that complete priority data accompanies *each order* in the form of certificates, endorsements properly signed, etc. The priority is not effective in scheduling shipment until it is received by your supplier.

Your needs and the war effort are best served by using the proper priority rating assigned by the War Production Board for the job involved, and requesting delivery no earlier than actually required.

Under the Production Requirements Plan, builders of motor-equipped machines for subsequent sale may order their requirements in advance.

check with G.E. for delivery from local warehouse stocks

To meet urgent war needs, a supply of standard Tri-Clad motors is maintained at G-E factories and local G-E warehouses. Perhaps the motor you want, or can use with a few simple changes, is available for immediate shipment.

Your local G-E motor representative can furnish information on motors which may be in stock in the following cities:

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Cleveland, Ohio
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Milwaukee, Wis.
Minneapolis, Minn.
New York, N. Y.
Oklahoma City, Okla.
Omaha, Neb.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Calif.
Seattle, Wash.

Topics

AS DISCLOSED in a recent congressional investigation of the bonuses distributed by The Lincoln Electric Co., improvements in manufacturing methods through new developments in machines and processes as well as wholehearted support of the workmen made possible the reduction of unit costs to a hitherto unbelievable level and at the same time increased profits beyond expectation. Mr. Lincoln attributes the success of his company primarily to the philosophy of using incentives, making each worker feel he is part owner of the business. He says, "The great problem we have is not more shipyards and more men but more efficiency with what we now have."

♦

INGENUITY in suggesting the right alternative material when bidding on government war jobs will render a real service to America, especially if a critical situation with respect to the specified material affects the speed of delivery, cost or rate of production. According to C. C. Struever of the American Nickeloid Co., many companies are saving as high as 98 per cent of critical materials through application of preplated metals. These metals, being steel for the most part, have the surface plated for the characteristics desired.

♦

POPULARITY of diesel engines is increasing by leaps and bounds. During the past ten years the total horsepower of all diesels produced in the country has increased from 100,000 to over 4,250,000 horsepower. Though this country has yet to develop the possibilities of diesel in aircraft, the axis nations have already adopted them for this use. Their economical advantages, however, indicate that it is only a question of time until they come into their own for airplanes in this country also.

♦

ELECTROLYTIC polishing of silver produces a surface with reflectivity as high as if not higher than mechanical polishing, according to disclosures at a recent meeting of the Electrochemical Society. Process depends upon careful control of current density and a bath of silver cyanide, potassium cyanide and potassium carbonate. The method affords a means of preparing silver specimens for etching and microscopic analysis without mechanically work-altering the surface layer.

♦

PRODUCTION of liquid-cooled engines with a power rating in the range of the largest air-cooled engines will be undertaken for the Navy by the Liquid Cooled Engine division of The Aviation Corp. This will be the first use of liquid-cooled engines by the Navy in this war. According to William F. Wise, executive vice president of the corporation, "I believe that it will not only contribute toward winning the war, which is uppermost in our minds, but will also figure very significantly in postwar developments."

♦

RECENT substitute for critical building supplies in England is a concrete-like product containing a large proportion of sawdust. It can be sawed or nailed like wood and, from a British production standpoint, is so light that women can do most of the work, including tending concrete mixers.

♦

ACCORDING to Maynard M. Boring, General Electric, "Jobs for engineering graduates last year were the most plentiful in twenty years and this year they are twice as numerous. It is estimated that there is a shortage of 82,000 technical graduates this year."

♦

NEW phenolic plastic has been developed which when molded has twice the shock resistance of general purpose materials. Produced to meet the needs of industry for a high impact-resisting plastic that can be preformed on automatic tableting machines, it is designated Bakelite XM-15,000.

♦

TWO thousand tons of copper will be obtained monthly by shredding used tin cans and shipping them to copper mines. There the mine water which contains copper sulphate will deposit copper in passing over the shreddings. The metal may then be readily processed.

Impregnated Plywood Becomes War Material

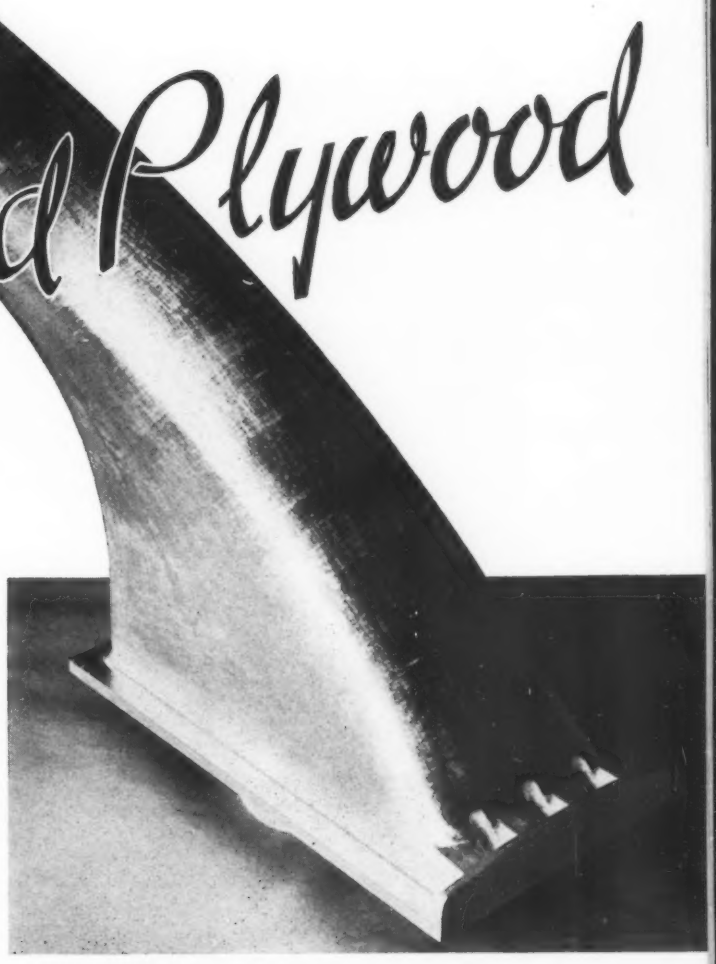


Fig. 1—Supercharger duct unit molded of fully-impregnated plywood indicates the possibilities of this material for mechanical parts

By John Delmonte
Technical Director
Plastics Industrial Technical Institute

MUCH attention has been centered lately upon the results achieved by fully impregnating woods with phenol-formaldehyde synthetic resins. This interest has been expedited in a large degree by the need for additional materials of construction in war industries. From the applications which have been developed and the improved properties obtained, this appears to be a promising combination. The resin imparts increased strength and permanence of quality which the average wood inherently does not possess. Typical applications requiring mechanical strength and durability are shown in *Figs.* 1 and 3.

So important are the developments of fully-impregnated woods that designers everywhere are

seeking information on the technique of impregnating various woods and on the properties of the final products. Impregnation of wood with phenolic resins is by no means new, the principle having been anticipated by Dr. Baekeland* as early as 1910. In this patent, reaction products of phenol and formaldehyde are caused to condense around the bundles of fibers in the wood structure. It is also pointed out that relatively soft woods can be transformed into harder varieties by this technique.

Since that time various investigators, notably those at the Forest Products Laboratory in Wisconsin, have examined the more fundamental aspects of the problems and have pointed the way to more practical ways of treating wood with phenolic resins. These techniques are not to be confused with the well known processes of laminating wood veneers whereby layers of wood are bonded together with the aid of phenolic or urea resins applied only at the interfaces between adjacent layers. Surface impregnation is only superficial by these processes, though, as T. Perry points out, superpressed plywood with multiple layers of phenolic resin film more closely resembles a fully impregnated wood†.

Penetration of phenolic resins into wood is not as simple as might be expected. If a sample of untreated wood is placed in a conventional alcohol solution of a phenolic laminating varnish the alcohol solvent will rapidly permeate through the wood, though the phenolic resin will diffuse and fill only the outer surfaces. On the other hand, if the wood veneer has been partially hydrolized to remove undesirable ingredients and to open up the structure, the wood can, upon prolonged immersion, be filled with an alcohol-soluble phenolic resin. The final products possess a density com-

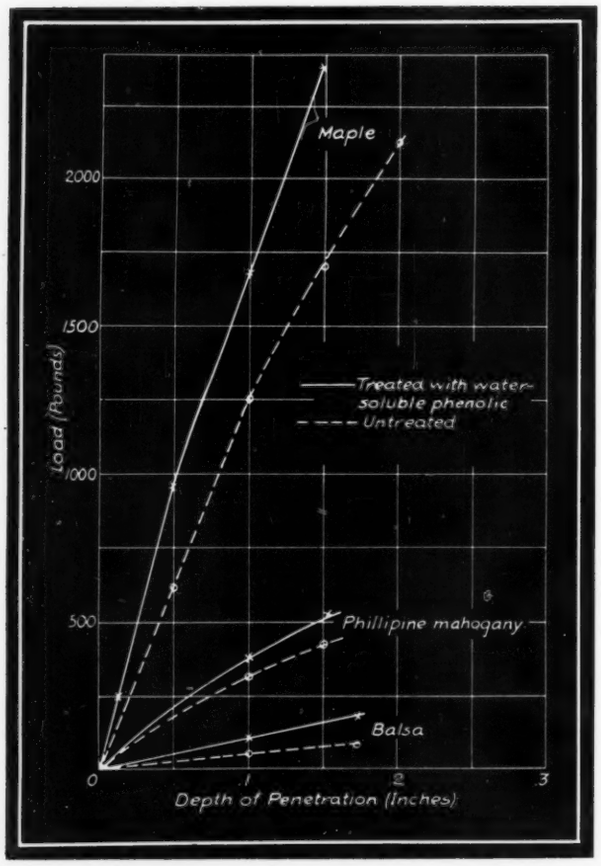


Fig. 2 — Increase of hardness with resin impregnation

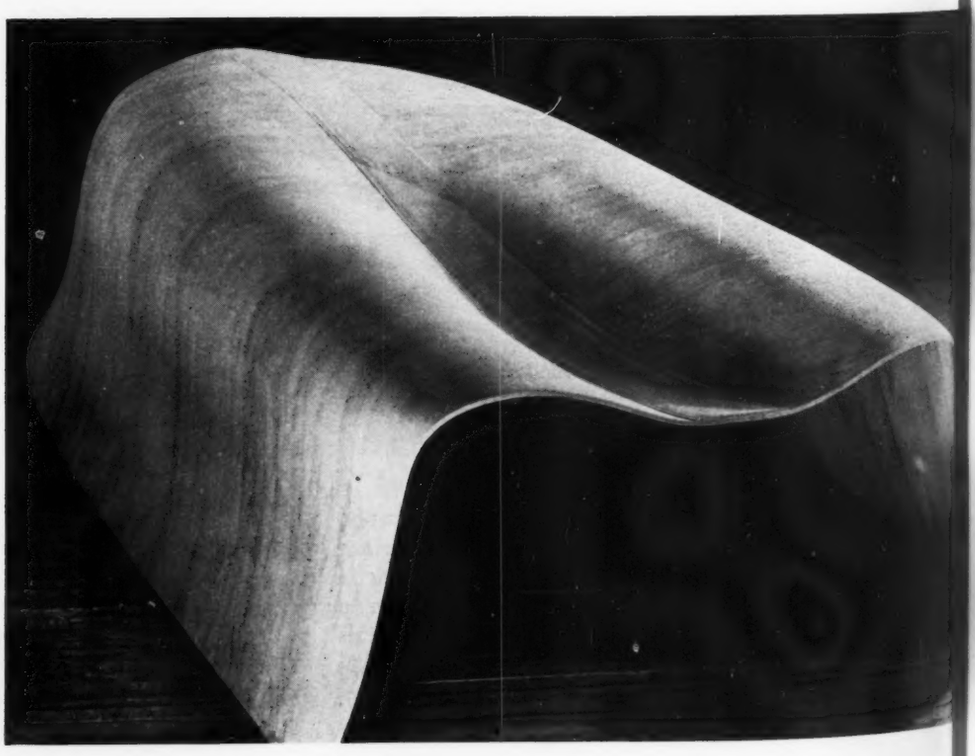


Fig. 3—Army boat hull formed in one piece of seven-ply resin-impregnated birch

— Photos Courtesy of United States Plywood Corp.

* Patent 949,671, issued February 15, 1910.
†*Mechanical Engineering*, March 1940, Page 389.

parable to other phenolics and require high temperatures of 2000 to 3000 pounds per square inch for laminating purposes. A substantially fully impregnated wood structure is obtained for which the following physical properties are representative.

Specific gravity	1.29
Tensile strength (with grain)	14,200 psi
Tensile strength (across grain)	2,300 psi
Compressive strength	13,400 psi
Flexural strength (with grain)	28,000 psi
Flexural strength (across grain)	3,000 psi

It should be recognized that in a product of this type the properties displayed are substantially those of the phenol-formaldehyde resin, the wood acting more as a filler due to its having been crushed by the high laminating pressures.

Much of the recent work performed upon fully-impregnated woods has been conducted with the aid of water-soluble phenolics. Early stage phenol dialcohols, dissolved in water, sometimes with the aid of some alcohol, are employed for impregnating purposes. The mechanism of penetration differs from that of alcohol-soluble phenolics in that smaller and lower molecular weight phenolic condensation products are employed. Unlike the heavier, larger alcohol-soluble resin, the water-soluble phenolics will diffuse through the intercellular walls of the wood structure without filling the lumens or spaces between the cell wall.

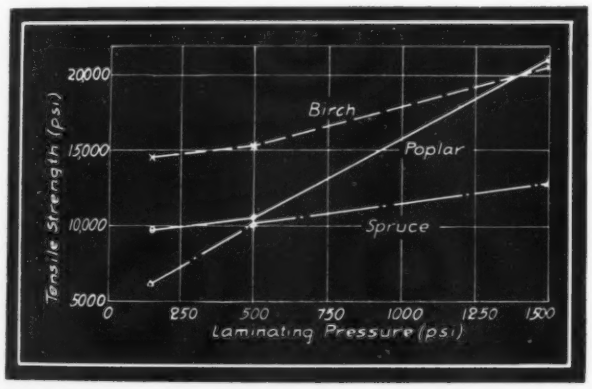


Fig. 4—Tensile strength for fully impregnated birch, poplar and spruce plotted against laminating pressures

From a practical point of view this means that a green, untreated wood will serve as the best medium for the diffusion of the water-soluble phenolic. Further, in the final product the physical properties will be predominantly influenced by the wood structure, with the phenolic resin guaranteeing quality. How the presence of these resins improved physical properties will be revealed by the later data.

Methods of impregnation depend largely upon the thickness of the wood sections being treated. Thin sections of less than 1/32-inch can be placed in the water-soluble resin for about ten minutes, and then allowed to air-dry about 48 hours at room temperature and relative humidity of about 50 per cent. Sections thicker than 1/16-inch should be placed under vacuum for about 10 minutes. Then the resin is drawn in for a period of time. After air-drying, the veneers should be oven-dried at about 180 degrees Fahr. for 30 minutes. In most cases they should then be ready for laminating purposes or for filling many applications required of the resin-impregnated types of wood.

For thicker sections more elaborate steps should be followed. The amount of absorption depends largely upon the species of the wood as well as its thickness. Basswood, maple, balsa, birch, and poplar have been observed to possess good impregnating characteristics. In general, the impregnation of thicker sections requires, in order, the application of vacuum, introduction of the water-soluble phenolic resin, then pressure for a period of time before impregnated samples are withdrawn from the bath and cured at an elevated temperature.

As compared with natural wood, there are numerous advantages in favor of the resin-impregnated types. These are as follows:

1. Less swelling than natural wood
2. Moisture travel through retarded
3. No further checking
4. Lower water absorption
5. No fungi growth
6. Harder surface and interior.

These are inducements to the machine designer contemplating the use of wood because without them wood would not be satisfactory for many mechanical parts. Perhaps the most important property of all is dimensional stability.

Improvement in hardness is illustrated in *Fig.* 2, which shows the resistance to penetration of a polished ½-inch diameter ball offered by representative samples of maple, mahogany and balsa wood. All samples are one-inch thick and im-

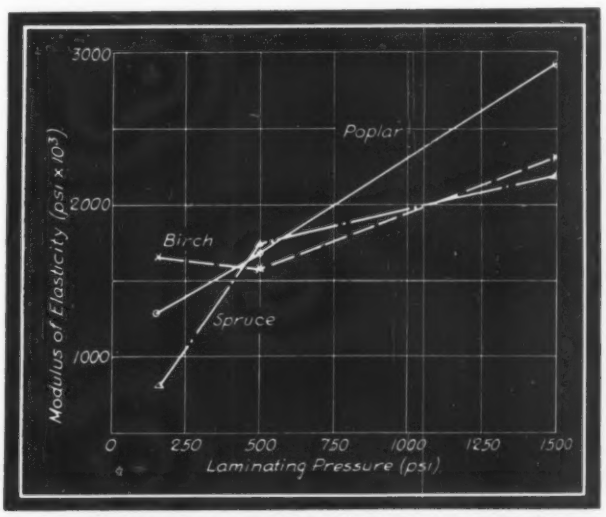


Fig. 5—Variations in modulus of elasticity with change in laminating pressure

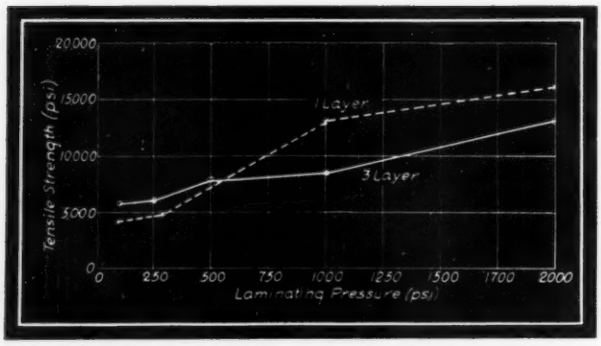


Fig. 6—Strength of resin-bonded plywood for comparison with fully impregnated types shown in Fig. 2

mersed in a water-soluble resin for 10 hours, air-dried for 48 hours, and baked at 290 degrees Fahr. for one hour. The steeper slope of the impregnated samples over untreated kinds indicates the beneficial action of the resin. Pressure was applied at a rate of .05-inch per minute in a universal testing machine. Tests were conducted across and parallel to grain and some comparative effects observed in all cases.

In TABLE I are shown the properties of phenolic resin-impregnated veneers. Inasmuch as there are numerous variables which affect results, the testing procedures and samples were standardized as far as possible. In all cases of the fully resin-impregnated samples the conditions remained the same and are listed below the table. Tensile strengths and moduli of elasticity for these conditions are shown graphically in *Figs.* 4 and 5.

TABLE I

Physical Properties of Phenolic Resin Impregnated Veneers*

Type of Veneer	Laminating Pressure (psi.)	Final Thickness (avg. in.)	Specific Gravity	Resin Content (avg. %)	Tensile Strength (psi.)	Modulus of Elasticity (psi.)
Birch ...	150	.115	.79	19	14,500	1,646,000
Birch ...	500	.104	.86	19	15,540	1,586,000
Birch ...	1,500	.076	1.15	19	20,501	2,331,000
Poplar ..	150	.125	.67	24	9,810	1,284,000
Poplar ..	500	.095	.90	24	10,415	1,656,000
Poplar ..	1,500	.068	1.27	24	21,330	2,930,000
Spruce ..	150	.121	.53	19	6,300	732,000
Spruce ..	500	.070	.84	19	10,070	1,705,000
Spruce ..	1,500	.050	1.19	19	11,600	2,234,000

*Specifications for specimens:
1. Initial moisture content, 5 to 7 per cent
2. Construction, 3-ply (two outer layers lengthwise and middle layer cross-grain)
3. Air dry after impregnation, 36-48 hours (further resin diffusion may occur during this period)
4. Preheat time (before laminating), 45 minutes at 200 degrees Fahr.
5. Lamination at 325 degrees Fahr. for 15 minutes
6. Removal from laminating press while hot
7. Veneer thickness: Poplar, .045-inch; spruce, .040-inch; birch, .040-inch.

Data which are reported are the average for three or four samples. Tensile tests and flexural tests were conducted in accordance with A.S.T.M. standards, whereas the moduli of elasticity were determined by beam deflection methods developed at this institute. Water-soluble phenolic resins were employed throughout most of the tests, though a comparison is made with an alcohol-soluble phenolic.

It is apparent from the tables that increased strength and modulus is a direct result of greater laminating pressure. What is most significant, however, from the machine designer's viewpoint is the percentage gain in strength for the increase in density. These comparisons are shown in TABLE II. Poplar and spruce gain in strength and modulus at a more rapid rate than in density and benefit decidedly from treatment with synthetic resins. This generally results in an increase in strength-weight ratio. The resin-impregnated woods compare favorably with steel and aluminum under these conditions.

For comparison purposes a few tests were performed upon .04-inch poplar bonded with a single

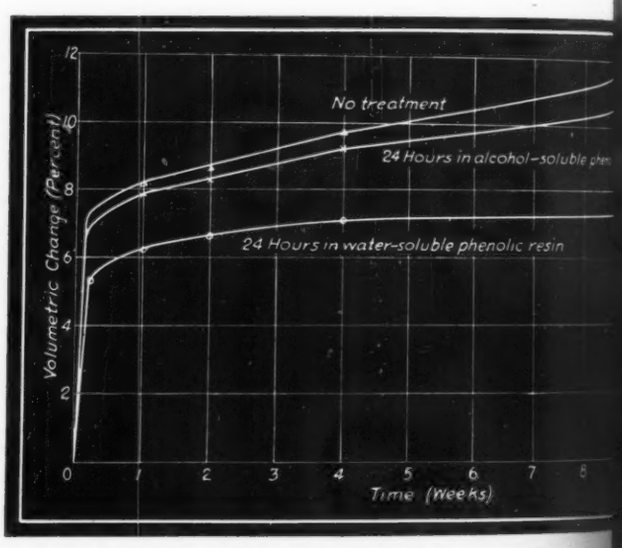


Fig. 7—Water absorption rates per twenty-four hours for birch and poplar with both alcohol and water-soluble phenolics

and three layers of phenolic resin films as a function of laminating pressures. Tensile strength for these are plotted in *Fig.* 6 and may be compared readily with *Fig.* 2 for relative strength of the fully impregnated type.

Test samples were identical to those which were fully impregnated. It is apparent that the water-soluble phenolics, diffused throughout the wood structure, gives higher strength values, at least for the poplar. The resin content is higher, only 8 per cent for poplar and 5.5 per cent for birch being reported by other sources‡ for single-film phenolic resin films in comparable tests.

Under vacuum conditions as much as 35 per cent water soluble phenolic resin content may be absorbed into the wood veneers of .04-inch thickness during one hour. This is based upon the final weight after solvent carrier is removed. However, in simple immersion such as was carried

‡T. Perry—*Modern Plastics,* May, 1942.

out for the wood veneers of this test, smaller amounts are absorbed. Typical results are shown in TABLE III.

It is possible that much of the alcohol-soluble resin remains on the surface of the veneer and does not impregnate the wood. This is observed experimentally by two important tests:

1. Water absorption of veneers treated with alcohol-soluble resin is higher than water absorption of same veneers treated with water-soluble phenolic resin
2. There is less dependence of plywood strength upon laminating pressure when alcohol-soluble phenolic treatments are employed than when water-soluble phenolic resins are used.

Dependence of water absorption characteristic of plywood upon the laminating pressure with water-soluble phenolics is illustrated in *Fig.* 7. The higher values which are experienced when a nonimpregnating alcohol-phenolic varnish is employed are also shown. The low water absorption of the resin-impregnated poplar is particularly noteworthy.

There are several ways of interpreting water absorption. When the lumen or spaces between

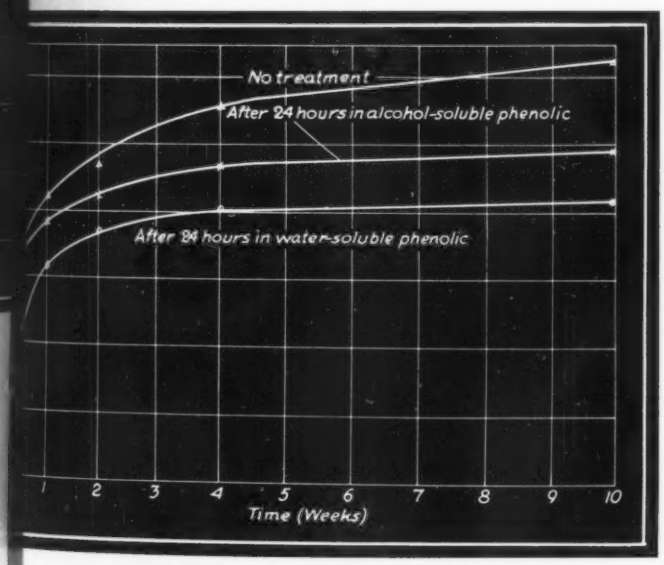


Fig. 8—Swelling in Oregon pine from immersion in water, compared with impregnated types

cellular walls are filled, the actual weight increase may be high. However, this does not imply dimensional instability, which depends upon absorption of resin by the cell walls. If however, during the application of a synthetic resin there is diffusion into the cell walls there is a decided improvement in dimensional stability. This fact has been brought out by Forest Products Laboratory. Some data are presented in *Figs.* 8 and 9 to show the effect of water upon resin treated woods during a ten-week immersion period.

Applications of resin-impregnated plywoods and high density plywoods (employing resin films) are increasing in scope and magnitude. Naturally, in the war effort some activities cannot be described at present. With existing shortages of metals it is well that machine designers become acquainted with these materials which are still in an early stage of development. The plywoods are not necessarily limited to flat sections. They can be formed like sheet material, preferably before the resin bonding agent has been fully cured. Boat hulls, aircraft panels, etc., are some of the earlier applications that are being served by these materials.

TABLE II

Effect of Increased Pressure

(Compared with 150 psi laminating pressure)

Material	Laminating Pressure (psi.)	Density (%)	Tensile Strength (%)	Modulus of Elasticity (%)
Birch	500	70	6.9	−3.8
Birch	1,500	45.5	43	41.6
Poplar	500	34	6.2	29
Poplar	1,500	89.5	117	128
Spruce	500	58.5	60	133
Spruce	1,500	119	84	205

TABLE III

Resin Absorption

Material	Thickness (inch.)	Time (min.)	Type of Phenolic	Resin Absorbed (per cent)
Birch	.040	60	Water-soluble under vacuum	36
Birch	.040	10	Water-soluble	17
Birch	.040	60	Water-soluble	26.5
Birch	.040	10	Alcohol-soluble	11
Birch	.040	60	Alcohol-soluble	15.5
Poplar	.045	10	Water-soluble	19.6
Poplar	.045	60	Water-soluble	27
Poplar	.045	10	Alcohol-soluble	12
Poplar	.045	60	Alcohol-soluble	18

The assistance of Mr. Friedman and Mr. Hemming Jr. of this institute in obtaining some of the test data used is gratefully acknowledged.

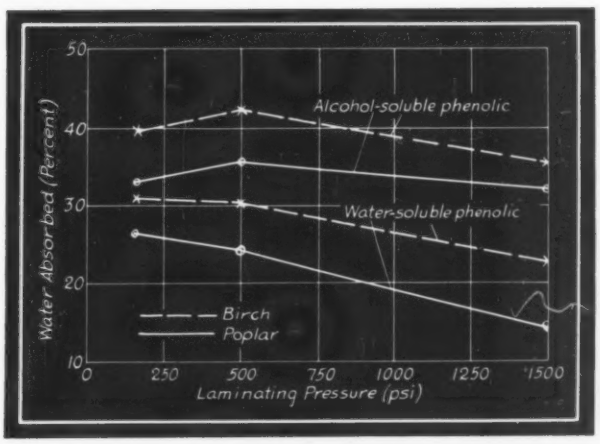
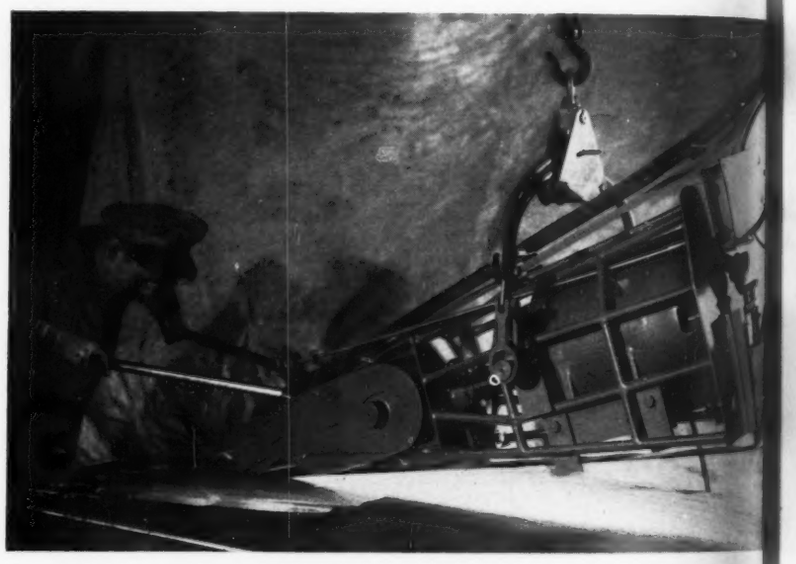


Fig. 9—Amount of water absorption by Oregon pine

IDEAS

Scanning the field for

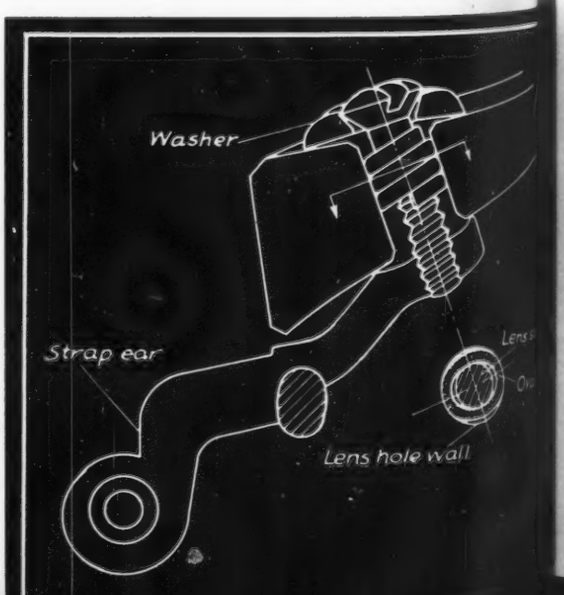
Balanced design for belt grinder obviates counterbalances and provides a heavy-duty, easily controlled, high production machine. Of welded tubular and plate construction, the grinder is powered by a five-horsepower motor contained within the frame and surrounded by the abrasive belt. Designed by the Jones Engineering Co., it combines the features of two conventional methods — the swing type employing snagging wheels and the portable disk grinder. When supported by its yoke the grinder is so balanced that it is highly maneuverable and may be operated in any position.



Controls consisting of a switch and belt tensioning device are conveniently mounted at the operator's position. The latter utilizes a rod with a knob at one end and universally connected at the other to a pair of bevel gears which control the position of the lower idler by an adjusting screw on a sliding way. Contact roll is driven by V-belt from a right-angle drive direct-coupled to the motor. This roll has a segmental face and imparts a fingering action in grinding.

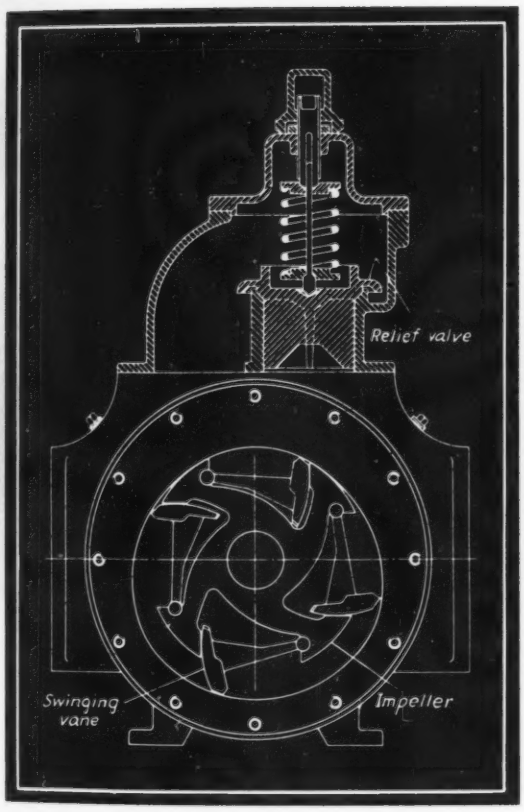
Where much metal is to be removed and smooth surfaces are required, this machine is particularly useful. It is employed in many war industries for deseaming and spot-grinding tubing, spot-grinding and finishing strip, conditioning breakdown plates, removing excess rolled-in scale or other defects.

Strain-relieved mounting as shown diagrammatically at right has been designed by Bausch and Lomb. Developed for eye glasses, it seemingly has possibilities also for military instruments. Conventional screw straps develop excess strain on the glass at the screw threads, especially for lenses with extremes in curvature. Self-seating to any section as indicated, the mounting employs a washer with a centering hole and an ear capable of conforming to the non-uniformity of the lens. A tiny coil strip spring, oval in shape and assembled around the screw, cushions the lens to absorb shock and reduce mounting strain as shown in the cross section of the lens hole. Extended



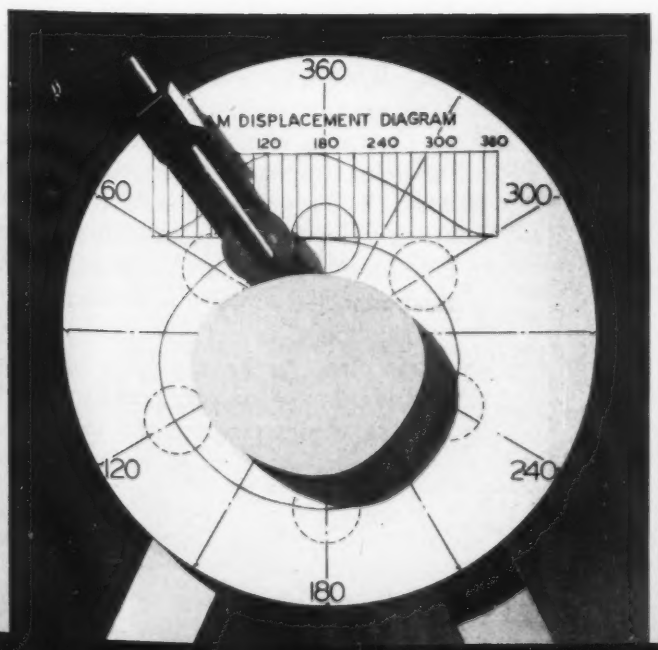
gripping surface of the washer and ear prevent chipping at the edges. With this method of assembly, mountings stay tighter because the tension of the spring keeps the screw from easily backing out.

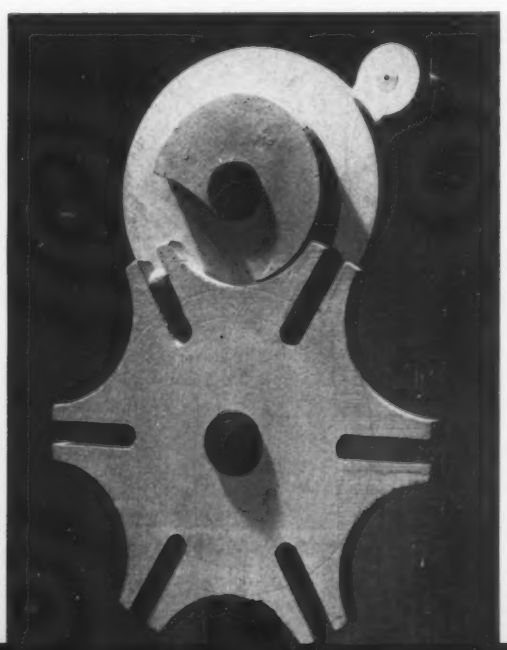
Centrifugal action on the swinging vanes of the rotary pump shown at left with a vane being inserted, and also in cross section below, provides pumping action by holding the tips of the vanes in contact with the pump liner while the impeller is rotating. Thus the only wear in the pump chamber is between the liner and the "bucket" tips and is readily compensated for by the centrifugal action. Designed by the Blackmer Pump Co., the unit is hydraulically balanced by having all surfaces of the vanes in contact with the pumpage. This allows for a minimum constant pressure between the swinging parts and liner to maintain an effective action throughout the operating range of the pump. Liners as well as individual buckets are readily replaced by removing the head plate and inserting the new parts. This is advantageous when handling extremely corrosive liquids.



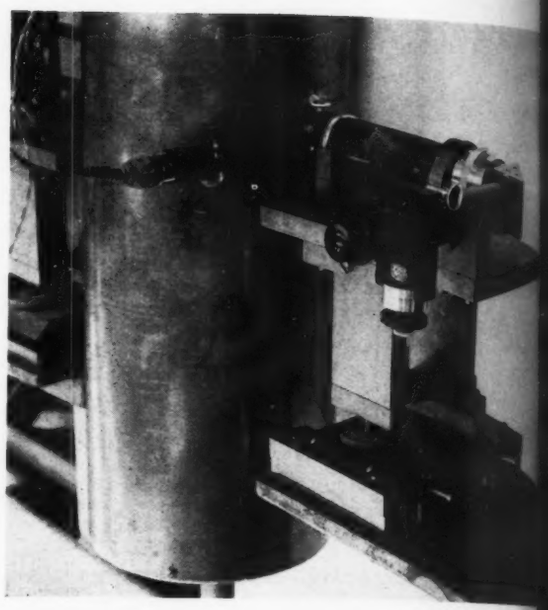
Visual aids facilitate student training in the design and operation of mechanisms and are particularly helpful in the accelerated pace of today's programs. Illustrated below are two of many kinematic models designed by the Pennsylvania State College and produced by the Works Progress Administration in Pennsylvania.

The cam model is an inversion of the conventional mechanism so designed as to show the method of drawing the cam profile. For this reason the cam is held stationary and the follower arm moves around it. In the other working model the well-known Geneva gear clearly demonstrates how dwell periods are obtainable. In this way a quick understanding is obtained which is not possible with "still" illustrations. Additional models in the group include: Epicycloid, slide

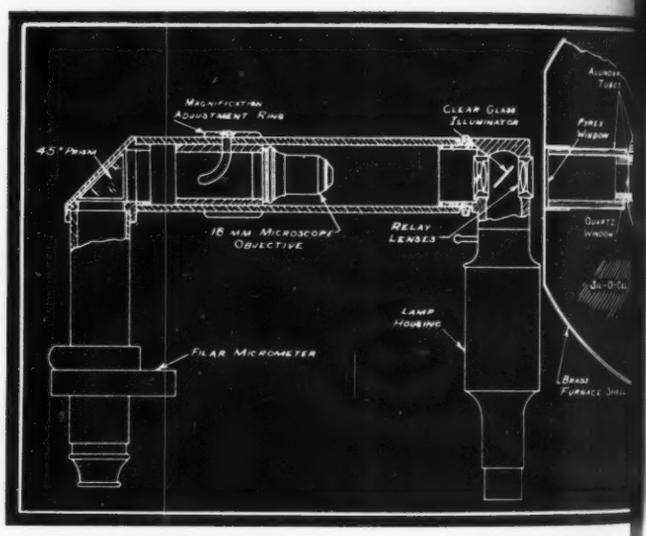


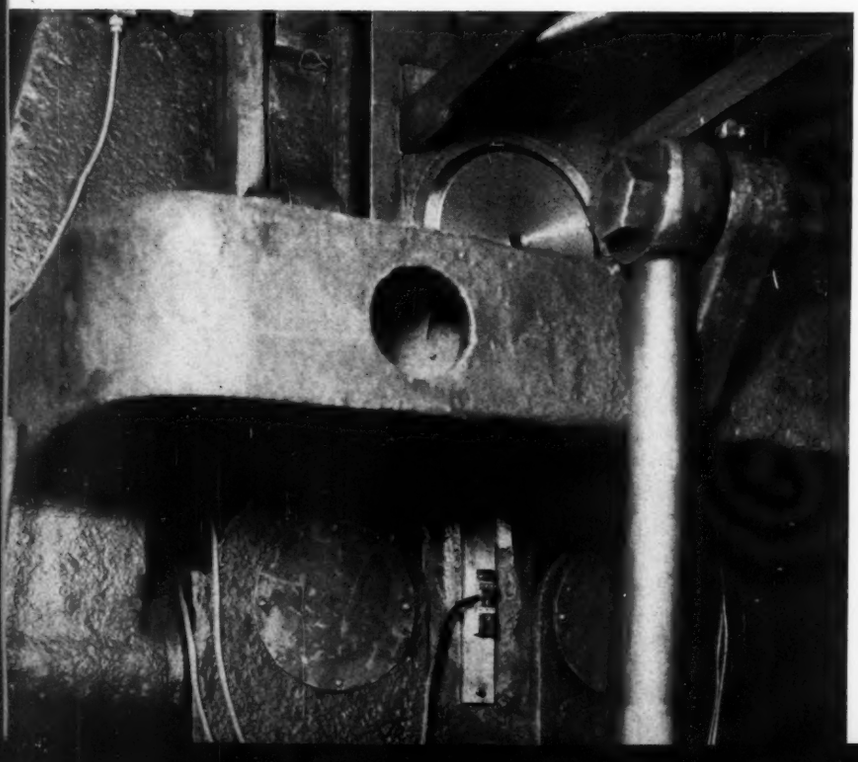


crank, straight-line motion, involute, belt and pulley, planetary gears, pantagraph, indicator motion, cylinder cam, Oldham coupling, Scotch yoke, positive cam with oscillating follower, gear tooth and Whitworth quick return.

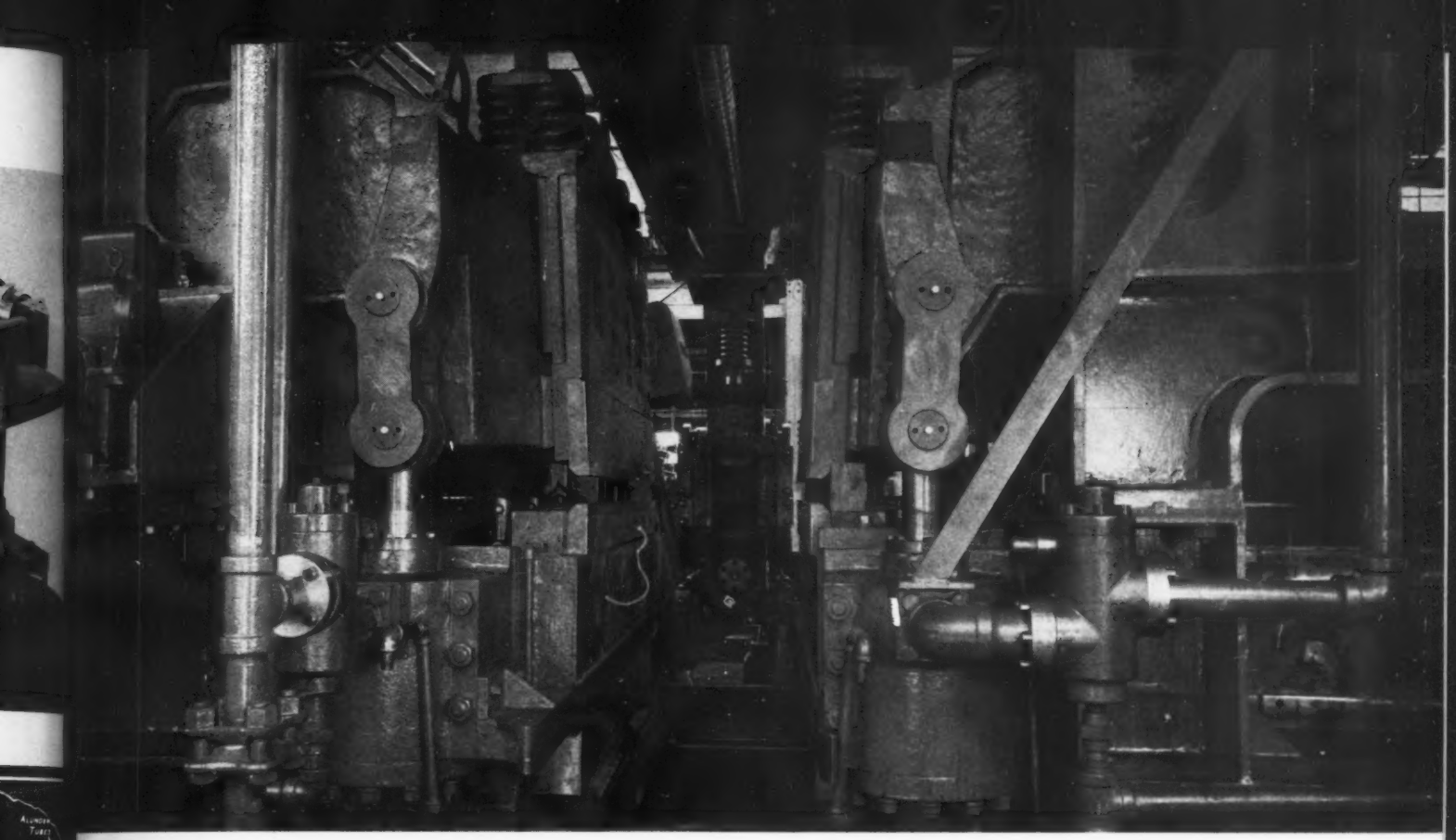


Measuring microscope, illustrated at right, has a total error of less than ±.00004-inch between observed readings. Developed at the National Bureau of Standards for use in creep-rate analysis and reported by Messrs. Bennett and McAdam, the instrument has no parts extending into the furnace. The microscope consists of a relay lens which forms a full-size image of reference marks, followed by an objective and eyepiece which give a magnification of about 75 diameters. Magnification can be adjusted by a collar which moves the objective relative to the relay lens and eyepiece. To facilitate measurement between compactly spaced furnaces and allow extensometer mountings between units, a right-angle prism is placed between the objective and eyepiece. Actual measuring is done with a filar micrometer. The microscope can be easily moved from one unit to another. Focusing is done by moving the whole mounting so that the unit is always in focus when set in the V-blocks which support it. Measurement of creep is accomplished by determining the distance between reference marks on two adjacent Nichrome gage bars with reference marks on platinum strips welded to the bars.





Overload protection by measuring the strain on machine parts subject to sudden loads is an effective method for keeping heavy-duty machines in production, especially now when machines are being worked to their utmost capacities to meet the production schedules set by our war requirements. If a part is being worked hard or a tool has become dull, there is danger of failure. Strain in the pyramid-type bending roll at left is measured by a G. E. electromagnetic strain gage mounted on the frame between the rolls, and is indicated on a dial at the operator's position. A warning signal is interconnected to warn of excessive loads. In application it is not necessary to apply the gage direct to the vital part but instead it may be attached to any part in which the stresses represent proportional loading.



War Needs Speeded by Resistance Welding*

By B. L. Wise

Chief Electrical Engineer
Federal Machine & Welder Co.

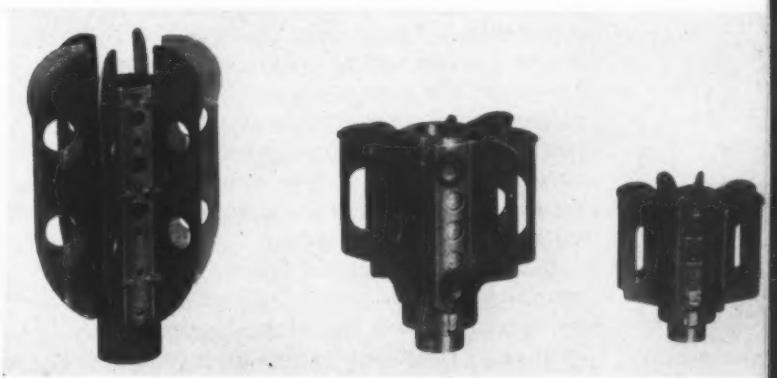
TECHNICAL progress in the field of creative science and in the science of production is the individual concern of everyone engaged in the war program. Dire competition exists entirely between our scientific and productive efforts, and those of the enemy. We must, therefore, design for and use those manufacturing facilities which are best adapted to the problems at hand or which can most easily be so adapted. We must use the process that will do the job more quickly, better than any other or with the fewest man hours and the least skilled help.

In discussing applications of the types of resist-

*Based on a paper presented at an American Welding Society meeting, Cleveland, May 8, 1942.

Fig. 1—Above—Clamping dies on flash welding machine which butt welds the ends of sheet to form continuous strip

Fig. 2—Below—Tail-fin assemblies for small bombs. Two at right show spot welds, the other projection welds



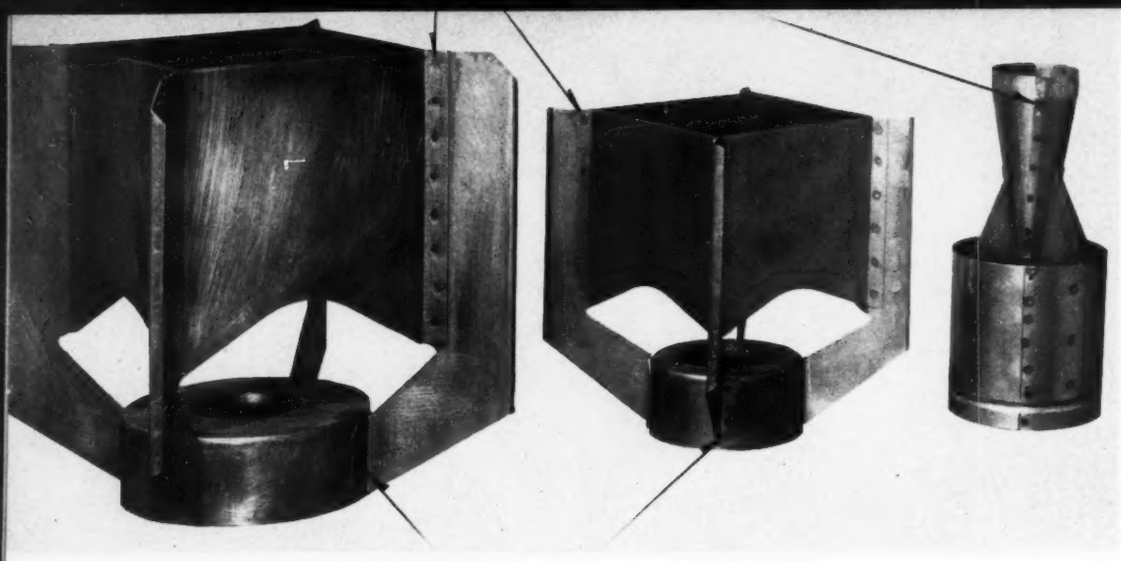


Fig. 3 — Left — Larger bomb tail-fin units than shown in Fig. 2. Spot welds are indicated on sheet metal stampings

Fig. 4—Below—Machine gun magazine part entirely fabricated from sheet steel stampings. Arrows pointing to rim welding show spot welds those pointing to edges of strip channels indicate hot riveting

ance welding to various war jobs, their general nature will be outlined briefly without revealing any restricted military information. Obviously some of the most important and the most interesting problems cannot even be mentioned. Of the resistance welding processes which are being used in our war program, the flash-butt welding process has promising possibilities, particularly in the field of heavy armament such as tanks, gun carriages, etc.

About ten years ago, a special flash-butt welder was developed for high-production welding of the longitudinal seam in the cylindrical portion of a barrel. Ordinary steel sheet, cut to size and preformed into a cylindrical shape with an open longitudinal seam, is welded to form a leakproof joint. This process came into considerable prominence during the early days of lend-lease aid to our allies. Exceptional production of these steel barrels was required for the transportation of oil, high-test aviation gasoline, petroleum products, alcohol, lacquers, chemicals, etc.

Now this same type of machine is being used for the production of ammunition boxes, depth bombs, chemical bombs, service containers, aerial bombs and medium pressure vessels. In addition, many special machines have been designed to accommodate different shapes and sizes of cylinders, having a more concentrated cross-sectional area. The limiting factor in the welding of any closed shape by this method is the ratio existing between the various dimensions. The thicker the plate, or the longer the cylindrical portion of the part, the larger the diameter must be to accommodate the necessary clamp furnishing the clamping pressure. Powder drum rings, turret rings and many circular shapes formed from bar or plate stock are welded on machines of this nature.

In the field of general flash welding, the number of the various devices fabricated by this means are almost too numerous to mention. Examples in this group are dis-

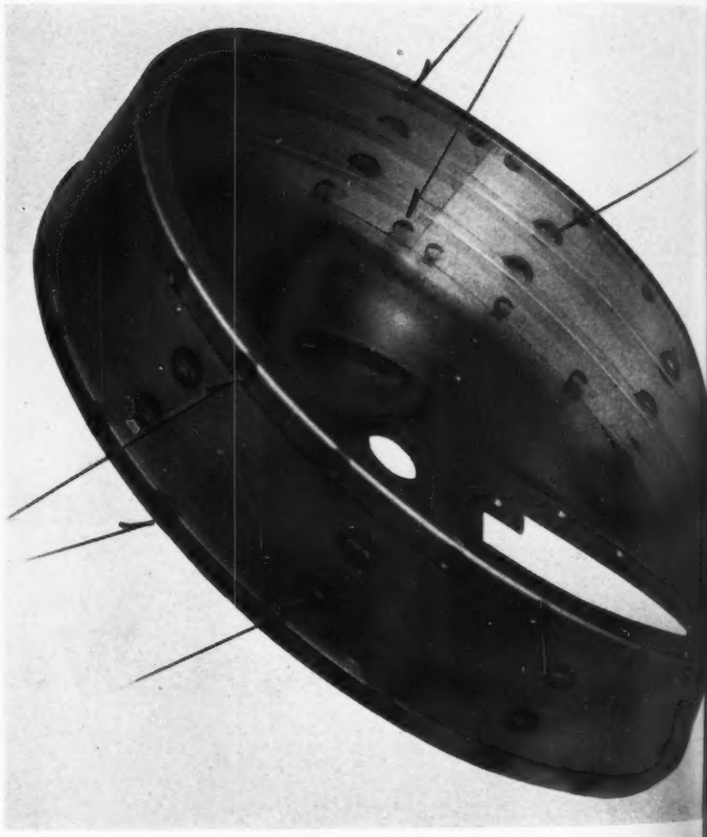
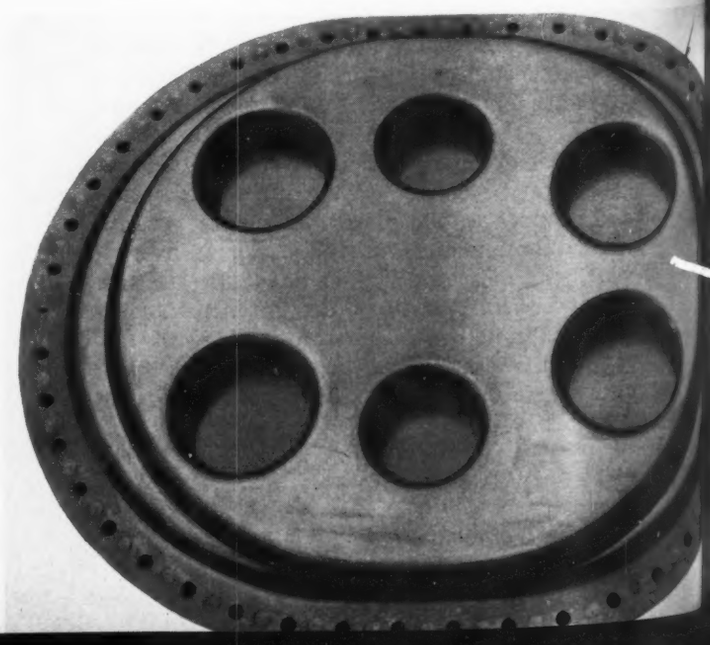


Fig. 5—Below—Aircraft subassembly of aluminum alloy utilizes spot welding to join outside flat sheet to inner reinforcing formed sheet. Upper arrow indicates a spot weld, lower shows a mounting hole



tinguished from the previous group by the fact that the parts to be welded are two separate and distinct pieces, whereas the previous examples were concerned with the welding together of the two opposite ends of the same piece of material.

There are two fundamental results from utilization of flash welding which may, in a large measure, determine the importance of this process. First: Savings in strategic and critical materials, accomplished by welding smaller pieces of a material to larger pieces of a less critical material. Second: Use of this process to conserve manpower and equipment.

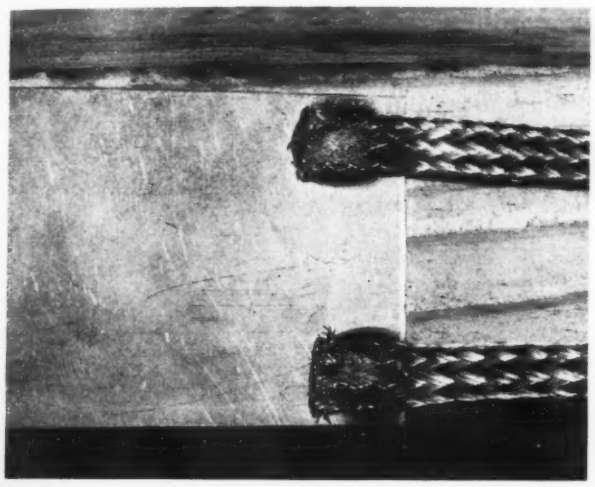
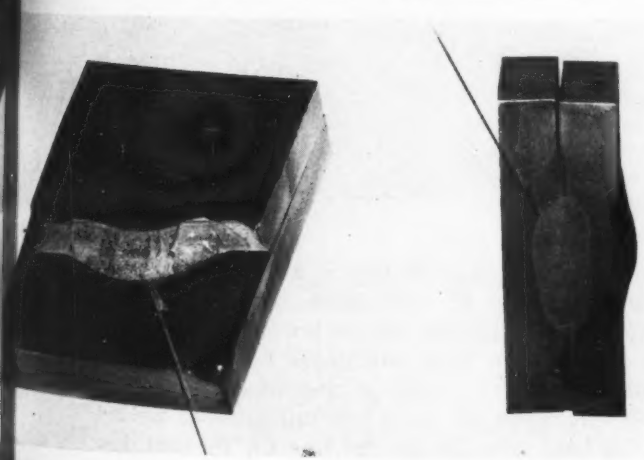


Fig. 6—Tin-coated copper braid spot-welded to cadmium plated steel saves solder and produces more flexible braids than was possible with previous methods

Fig. 7—Below—Test specimens of spot-welded armor plate. Destructive tensile test at left shows break beyond the weld. Section specimen at right is typical weld nugget and shows penetration of weld



In the savings of strategic material, the flash welding of low alloy drill shanks and drill extensions to ordinary and special twist drills—particularly highspeed drills—has accomplished savings of considerable consequence in the materials and in the cost of the fabricated assembly. Welding of high-heat resisting valve heads to the valve stems of internal combustion engines has likewise conserved strategic materials and has resulted in a valve assembly that is both better and cheaper than the previous assembly. This process had been developed and used to a limited extent before the present emergency but is now of much greater importance. The welding of stainless steel to mild steel has enabled the designers of many war items to retain the advantages of the stainless steel in their design, with the use of only one-fourth to one-half of the stainless previously used.

It is also possible to flash weld large sections of armor plate without the use of stainless steel welding rod and skilled operators. Ballistic tests on flash-welded armor indicate such a superior performance that a tank arsenal is now in the process of construction for the complete flash welding of tank hulls. The saving in time, and particularly in man-hours, by this process, on 1 and 1½-inch thick armor plate, is of considerable consequence.

Fig. 8—Stainless steel aircraft engine exhaust stack. The flanged edges are seam welded as indicated by arrows, while center arrow at junction between ports shows spot welds

In *Fig.* 1 is shown a close-up view of the clamping dies for a machine used in flash welding the trailing edge of one sheet to the leading edge of the next from a 96-inch strip mill. Trimming cutters, shown in the retracted position, mill the edges of the sheets square with each other. After welding, the flash is trimmed in the machine and the sheet continues as an integral part of the strip.

Welding strip material, end to end, to produce a continuous strip permits the use of continuous processes without necessitating re-threading. In many cases it is not necessary to give any further

consideration to the weld, and the welded portion goes through all of the subsequent processing operations as an integral part of the sheet or strip. This is true even though the subsequent operations may involve some rather deep-drawing.

Shortage of wide sheet and plate material has seriously threatened some large forming and stamping operations. By flash welding two or more smaller sheets or plates it is possible to continue these processes with no increase in cost, because of the elimination of the higher premium charge for the larger widths.

Flash welding is widely used in joining simple parts to produce complicated assemblies. These may involve simple castings, forging, stamping, or

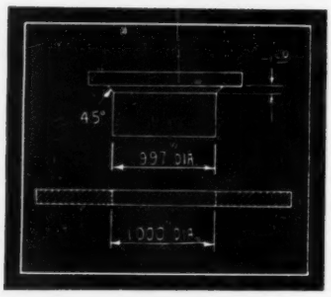


Fig. 9—Insert is welded to sheet by ring-projection welding. Details of assembly are shown in drawing at left

screw machine parts. The resulting savings in material and labor constitute a recognizable factor in speeding production. The parts themselves follow no standard pattern, and the variations and applications of the assemblies beggar description.

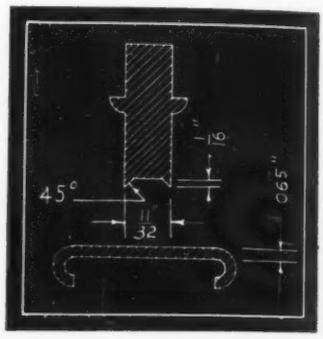
Spot and Seam Welding Used Extensively

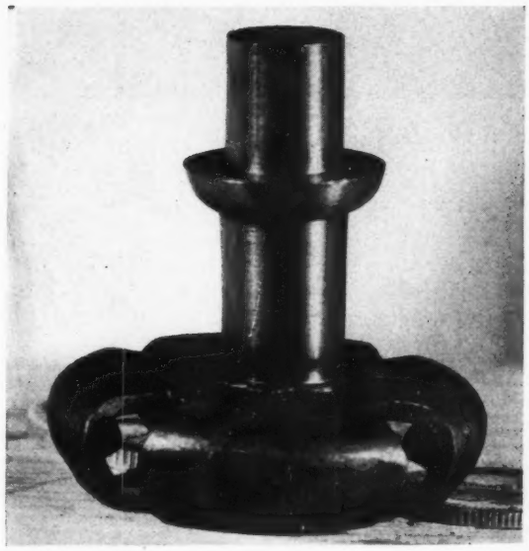
In the more usual forms of resistance welding —spot, seam and projection—it is even more difficult to give a representative cross section of the war articles involved. To cover the war materials fabricated by the use of these methods would almost require a complete list of war materiel.

Ordnance departments of both the Army and Navy were quick to recognize this production tool before the advent of the war in Europe. Even at that early date resistance welding manufacturers were performing considerable experimental and research work in co-operation with the various branches of the armed services, and in conjunction with the military commissions of the allies. This foresight on the part of the services can be recognized by the fact that resistance welding was incorporated in a large portion of the designs for armament from the outset of our war effort.

A few applications of spot, seam and projection welding will suffice to indicate the extent of utilization. Most of the following assemblies use at least two of these processes, many of them use all three and some include flash welding: Round bombs, anti-tank mines, parachute flares, chemical bombs, incendiary bombs, demolition bombs, trench

Fig. 10 — Below — Ring-projection welded assembly would become relatively costly if fabricated by other methods. Drawing shows detail of ring-projection welded assembly





mortar bombs, practice bombs and tail-fin assemblies for almost all types of bombs.

Small bomb tail-fin assemblies shown in *Fig.* 2 are produced in large quantities on specially designed automatic welding machines. The two shown at the right have the tail fin spot welded to the base plug while the one on the left has the fins attached to the plug by projection welding. Of particular note is the fact that the projection-welded design produces a cleaner assembly. Excessive heat marks are visible on the spot-welded assemblies, especially the center one.

In *Fig.* 3 are larger units employing a somewhat different design. The fins are almost entirely sheet metal stampings and are in the major part spot welded together. The welding of the fins themselves to the base cap is accomplished by either spot or projection welds. Another interesting ap-

(*Continued on Page* 136)

New Steels Conserve Vital Alloying Elements

ACUTE shortages of nickel and chromium focus attention of engineers on the newly-developed national emergency steels, here listed with more highly alloyed steels which they replace

WAR has drastically cut the supply of vital alloying materials and simultaneously increased the demand for highly alloyed steels for military uses. Conservation of critical alloying materials, particularly nickel and chromium which thus are released for military purposes, is being accomplished by the adoption of a new series of low-alloy steels designated the NE (National Emergency) series. Worked out by the American Iron and Steel Institute and the Society of Automotive Engineers, co-operating with the Army, Navy, Bureau of Standards and other government departments, at the request of the War Production Board, the new steels are balanced analyses in which molybdenum replaces more critical elements. Analyses of the new steels appear in TABLE I, together with particulars of five new standard steels of the molybdenum series which also are available as alternatives.

TABLE I

Available Alloy Steels

SAE or AISI Number	C	Mn	Ni	Cr	Mo
A 4027	.25-.30	.70- .90	.....	.....	.20-.30
A 4037	.35-.40	.75-1.00	.....	.....	.20-.30
A 4063	.60-.67	.75-1.00	.....	.....	.20-.30
A 4068	.64-.72	.75-1.00	.....	.....	.20-.30
A 4125	.23-.28	.70- .90	.....	.40-.60	.20-.30
NE 8024	.22-.28	1.00-1.30	.....	.....	.10-.20
NE 8124	.22-.28	1.30-1.60	.....	.....	.25-.35
NE 8233	.30-.36	1.30-1.60	.....	.....	.10-.20
NE 8245	.42-.49	1.30-1.60	.....	.....	.10-.20
NE 8339	.35-.42	1.30-1.60	.....	.....	.20-.30
NE 8442	.38-.45	1.30-1.60	.....	.....	.30-.40
NE 8447	.43-.50	1.30-1.60	.....	.....	.30-.40
NE 8547	.43-.50	1.30-1.60	.....	.....	.40-.60
NE 8620	.18-.23	.70- .95	.40-.60	.40-.60	.15-.25
NE 8630	.27-.33	.70- .95	.40-.60	.40-.60	.15-.25
NE 8724	.22-.28	.70- .95	.40-.60	.40-.60	.20-.30
NE 8739	.35-.42	.75-1.00	.40-.60	.40-.60	.20-.30
NE 8744	.40-.47	.75-1.00	.40-.60	.40-.60	.20-.30
NE 8749	.45-.52	.75-1.00	.40-.60	.40-.60	.20-.30
NE 8817	.15-.20	.70- .95	.40-.60	.40-.60	.30-.40
NE 8949	.45-.52	1.00-1.30	.40-.60	.40-.60	.30-.40

All of the above steels contain .20-.35 silicon and .040 maximum each sulphur and phosphorus. In addition to the above, the usual plain carbon (1000 series), high sulphur (1100 series), high phosphorus (1200 series), silico manganese (9200 series) steels are available in the various carbon ranges, as are certain other carbon molybdenum (4000 series) steels.

TABLE II

Standard Carburizing Steels

Standard Series Designation	Possible Alternatives: C-Mo Series	Cr-Mo Series	Mn-Mo Series	Ni-Cr-Mo Series
A 1320	A 4027	.....	NE 8024	.....
A 2317	A 4027	A 4125	NE 8024	NE 8620
A 2515	A 4027	.....	.....	NE 8817
A 3120	A 4027	A 4125	NE 8024	NE 8620
A 4119	A 4027	.....	NE 8024	.....
A 4120	A 4027	A 4125	NE 8024	.....
A 4320	.....	.....	NE 8124	NE 8724
A 4620	A 4027	A 4125	NE 8024	NE 8620
A 4820	.....	.....	NE 8124	NE 8724
A 5120	A 4027	A 4125	NE 8024	.....
A 6120	A 4027	A 4125	NE 8024	NE 8620

Limitation of the number of standard steels carries a step further the recent revision of steel specifications undertaken by the A.I.S.I. and S.A.E., the purpose of which was to simplify the problems of both producers and consumers by eliminating many alloys with closely similar properties. Deliveries and service are thus expedited and advances in manufacturing practices and quality more readily achieved. Designers will appreciate the resulting simplification of the problem of alloy steel selection.

These new alternative steels are intended to replace alloy steels in which the alloying elements do not exceed the following percentages: nickel 5.25, chromium 3.99, manganese 2.00, silicon 2.25, vanadium .25 and molybdenum 1.00. Comparison of TABLE I with these limits indicates the impressive saving of nickel and chromium possible, but at the same time it is evident that the new steel will not replace high-tensile strength alloys requiring no heat treatment, stainless steels, medium chromium steels used to resist scaling at high temperatures or tool steels.

Steels which can be replaced by the new series

TABLE III

Semithorough Hardening Steels

Standard Series Designation	Possible Alternatives		
	C-Mo Series	Mn-Mo Series	Ni-Cr-Mo Series
A 1330	A 4037	NE 8233	.....
A 2330	A 4037	NE 8233	NE 8630
A 3130	A 4037	NE 8233	NE 8630
A 4130	A 4037	NE 8233	NE 8630
A 5130	A 4037	NE 8233	.....
SAE 6130	A 4037	NE 8233	NE 8630

are conveniently classified as carburizing, semithorough hardening and thorough hardening. The standard steels, with their alternatives, which fit these classifications are listed in TABLES II, III and IV. Letter A in the standard series designation denotes a basic open hearth steel, and the digits denote the composition in accordance with the system adopted by the S.A.E. and A.I.S.I., TABLE V, in which the first two digits represent the principal alloying materials and the last two the points of carbon present. In TABLE IV the letters WD stand for War Department; these steels do not belong to the S.A.E.-A.I.S.I. standard series.

TABLE IV

Thorough-Hardening Steels

Standard Series Designation	Possible Alternatives		
	C-Mo Series	Mn-Mo Series	Ni-Cr-Mo Series
A 1340	A 4047	NE 8245	.....
A 2335	A 4063	NE 8339	NE 8739
A 2340	A 4068	NE 8442	NE 8744
A 2345	A 4068	NE 8447	NE 8749
WD 2350	A 4068	NE 8547	NE 8949
A 3045	A 4068	NE 8442	NE 8744
A 3135	A 4063	NE 8339	NE 8739
A 3140	A 4068	NE 8442	NE 8744
A 3141	A 4068	NE 8447	NE 8749
A 3145	A 4068	NE 8447	NE 8749
A 3150	A 4068	NE 8547	NE 8949
A 3240	A 4068	NE 8442	NE 8744
WD 3250	A 4068	NE 8547	NE 8949
A 4137	A 4063	NE 8339	NE 8739
A 4142	A 4063	NE 8442	NE 8744
A 4145	A 4068	NE 8447	NE 8749
A 4150	A 4068	NE 8547	NE 8949
A 4340	A 4068	NE 8547	NE 8949
A 4640	A 4063	NE 8339	NE 8739
A 4645	A 4068	NE 8447	NE 8744
4650	A 4068	NE 8547	NE 8949
A 5045	A 4063	NE 8339	.....
A 5140	A 4063	NE 8339	.....
A 5145	A 4068	NE 8442	.....
A 5150	A 4068	NE 8447	.....
WD 6140	A 4063	NE 8339	NE 8739
A 6145	A 4068	NE 8442	NE 8744
A 6150	A 4068	NE 8447	NE 8749
A 9260	A 4068	.....	.....

Currently used standard grades of semithorough hardening steels, TABLE III, consist of water-hardening and oil-hardening grades, generally used in tensile strength ranges from 100,000 to 150,000 pounds per square inch and in brinell hardness number ranges from 200 to 300. Some are used in the normalized or normalized and tempered condition with tensile strength values of 65,000 to 105,000 pounds per square inch.

Thorough-hardening alloy steels, TABLE IV, may be divided into five distinct classes as follows:

(a) Those used in the fully hardened state, tempered to about 400 degrees Fahr. with resultant brinell of 550 to 600; tensile strengths 275,000 to 300,000 pounds per square inch

(b) Those treated to brinell 350 to 450 with tensile strengths 175,000 to 225,000 pounds per square inch

(c) Those treated to brinell 260 to 350 with tensile strengths 125,000 to 170,000 pounds per square inch.

(d) Special alloy steels containing about .6 per cent carbon, used for such purposes as piston rods, rams, sow blocks, trimmer dies, shear blades and hot-work dies. These steels are usually chromium-nickel, chromium-nickel-molybdenum-copper and chromium-nickel-molybdenum-vanadium steels. It will be difficult to duplicate their properties with other analyses except where some experience has been gained,as for example manganese-molybdenum steels for shear blades

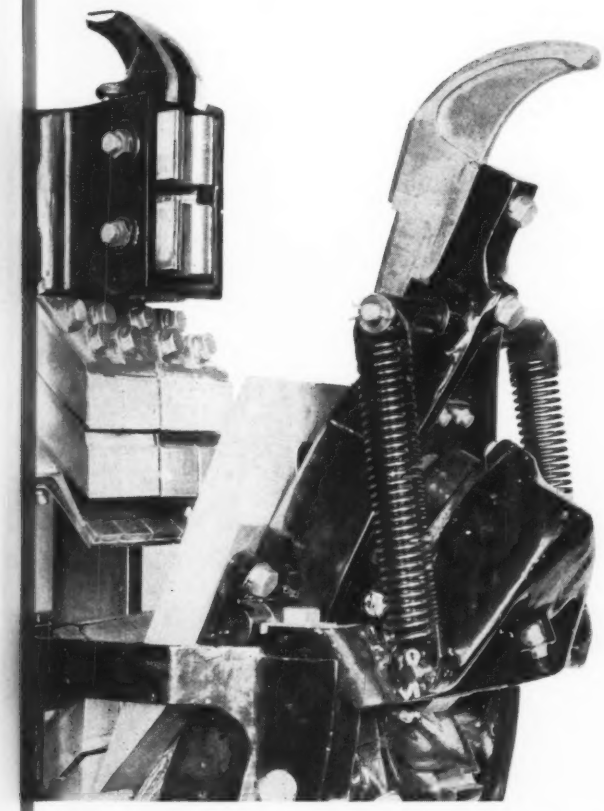
(e) High carbon alloy types such as the 52000 series steels of unusually high wear-resistance. Such steels are used at the maximum hardness obtainable. Emergency alternatives for these have been recommended by the Antifriction Bearing Manufacturers association, and are described in A.S.T.M. specification ES-5.

Further information covering the new steels will be published in subsequent issues of MACHINE DESIGN when available in complete form.

TABLE V

Alloy Steel Designations

Series Designation	Principal Alloying Elements and Percentages
13xx	Manganese 1.60 to 1.90
23xx	Nickel 3.50
25xx	Nickel 5.00
30xx	Nickel .50—Chromium .50
31xx	Nickel 1.25—Chromium .60
32xx	Nickel 1.75—Chromium 1.00
33xx	Nickel 3.50—Chromium 1.50
40xx	Molybdenum
41xx	Chromium-molybdenum
43xx	Nickel-chromium-molybdenum
46xx	Nickel 1.65—Molybdenum .25
48xx	Nickel 3.25—Molybdenum .25
50xx	Low chromium
51xx	Medium chromium
52xxx	Chromium, high-carbon
61xx	Chromium-vanadium
8000	Manganese 1.15—Molybdenum .15
8100	Manganese 1.45—Molybdenum .30
8200	Manganese 1.45—Molybdenum .15
8300	Manganese 1.45—Molybdenum .25
8400	Manganese 1.45—Molybdenum .35
8500	Manganese 1.45—Molybdenum .50
8600	Nickel .50—Chromium .50—Molybdenum .20
8700	Nickel .50—Chromium .50—Molybdenum .25
8800	Nickel .50—Chromium .50—Molybdenum .35
8900	Nickel .50—Chromium .50—Molybdenum .35
92xx	Silicon-manganese



Springs in circuit breaker mechanisms operating only occasionally may be considered statically loaded

When Springs Are Statically Loaded

By A. M. Wahl
Westinghouse Research Laboratories

TO facilitate the design of statically loaded helical springs, the accompanying tables and charts have been developed. They are based on the assumption that stress concentration effects due to bar or wire curvature may be neglected in calculating stress for springs subject to such loading conditions. This type of loading may be considered to exist where the load remains constant or is repeated relatively few times during the service life of the spring. Examples are safety valve springs, springs to provide gasket pressure and springs in mechanisms which operate rarely.

Although for static loading the localized stress caused by bar or wire curvature may be neglected, this is not true of the stress augment due to the direct shear produced by the axial load. The stresses due to this latter effect are not localized but are distributed more or less uniformly over the entire cross section, and hence should be considered in calculating stress.[1] To calculate the stress by neglecting the stress augment due to curvature but including that due to direct shear, the average shear stress from the axial load (which is equal to the load P divided by the sectional area) is added to the torsion stress figured by considering the spring wire as a straight bar under torsion. This gives for the maximum shear stress,

$$\tau_m = \frac{16Pr}{\pi d^3} + \frac{4P}{\pi d^2} \quad \ldots\ldots (1)$$

In this d = wire diameter, r = mean coil radius. This equation may be written

$$\tau_m = \frac{16Pr}{\pi d^3} K_s \quad \ldots\ldots (2)$$

where

$$K_s = 1 + \frac{.5}{c} \quad \ldots\ldots (3)$$

$$c = \frac{2r}{d} = \text{spring index} \quad \ldots\ldots (3a)$$

Solving Equation 2 for P,

$$P = \frac{\pi d^3 \tau_m}{16 r K_s} \quad \ldots\ldots (4)$$

The usual deflection formula for helical springs is

$$y = \frac{64Pr^3}{Gd^4} \quad \ldots\ldots (5)$$

where y = deflection per turn and G = torsional

[1] See "Calculating Springs for Static Loading", MACHINE DESIGN, June, 1941.

Loads and Deflections Per Turn for Statically-Loaded Helical Springs

Outside Diameter of Springs (inches)

Wire Diam. inches		1/8	5/32	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-5/8	1-3/4	1-7/8
.014	P	.912	.720	.596	.441	.352	.293													
	y	.0228	.0378	.0570	.106	.172	.253													
.016	P	1.372	1.09	.900	.664	.529	.438	.376												
	y	.0189	.0319	.0478	.0910	.1465	.218	.302												
.018	P	1.98	1.55	1.275	.952	.753	.625	.538	.470											
	y	.0162	.0273	.0413	.0794	.1285	.191	.266	.352											
.020	P	2.73	2.15	1.76	1.31	1.04	.860	.735	.644											
	y	.0139	.0238	.0365	.0702	.114	.169	.234	.312											
.022	P	3.66	2.87	2.37	1.75	1.395	1.145	.981	.855	.686										
	y	.0119	.0207	.0319	.0620	.102	.151	.208	.279	.449										
.024	P	4.77	3.76	3.07	2.28	1.81	1.50	1.27	1.115	.888										
	y	.0104	.0183	.0284	.0557	.0918	.137	.191	.254	.410										
.026	P	6.15	4.80	3.97	2.92	2.31	1.91	1.62	1.42	1.13										
	y	.00915	.0163	.0257	.0499	.0830	.125	.173	.231	.373										
.028	P	7.76	6.08	4.93	3.66	2.90	2.39	2.03	1.77	1.41	1.18									
	y	.00811	.0146	.0228	.0457	.0756	.114	.160	.214	.344	.506									
.030	P	9.60	7.5	6.12	4.52	3.59	2.93	2.52	2.19	1.74	1.445									
	y	.00715	.0130	.0206	.0416	.0685	.1045	.1475	.198	.317	.468									
.032	P	11.8	9.12	7.52	5.47	4.31	3.56	3.07	2.66	2.12	1.77	1.51								
	y	.00638	.0116	.0188	.0383	.0638	.0960	.1365	.182	.294	.437	.603								
.034	P	14.4	11.1	9.07	6.64	5.22	4.32	3.68	3.23	2.54	2.12	1.80	1.56							
	y	.00574	.0106	.0172	.0351	.0591	.0899	.1265	.170	.275	.407	.563	.762							
.036	P		13.3	10.8	7.94	6.21	5.14	4.35	3.82	3.01	2.51	2.15	1.86							
	y		.00962	.0156	.0327	.0549	.0835	.118	.159	.257	.382	.529	.701							
.038	P		15.6	12.8	9.32	7.30	6.05	5.15	4.52	3.54	2.97	2.54	2.20	1.96						
	y		.00869	.01435	.0299	.0508	.0782	.1105	.150	.241	.361	.500	.662	.842						
.040	P		18.3	15.1	10.9	8.55	7.05	6.05	5.23	4.16	3.42	2.96	2.57	2.28						
	y		.00792	.0132	.0277	.0475	.0728	.104	.140	.228	.338	.472	.625	.800						
.042	P		21.6	17.5	12.8	9.80	8.24	7.00	6.06	4.84	3.99	3.40	2.98	2.65	2.37					
	y		.0073	.0121	.0259	.0439	.0685	.0978	.132	.217	.320	.445	.591	.760	.941					
.044	P			20.1	14.6	11.45	9.46	8.06	6.98	5.57	4.62	3.92	3.41	3.03	2.72					
	y			.0111	.0239	.0415	.0641	.0910	.1235	.204	.304	.419	.558	.717	.897					
.046	P			23.2	16.8	13.2	10.85	9.21	8.01	6.35	5.27	4.48	3.92	3.48	3.14					
	y			.0104	.0224	.0389	.0605	.0858	.118	.193	.289	.401	.533	.685	.856					
.048	P			26.6	19.2	15.0	12.3	10.5	9.17	7.24	6.00	5.10	4.46	3.94	3.55	3.25				
	y			.00952	.0209	.0368	.0571	.0821	.112	.185	.275	.380	.509	.651	.820	.998				
.051	P			32.5	23.1	18.1	14.9	12.6	10.9	8.68	7.20	6.13	5.35	4.74	4.27	3.89	3.55			
	y			.00856	.0189	.0338	.0525	.0752	.103	.170	.256	.356	.476	.611	.763	.937	1.12			
.055	P				29.3	22.9	18.8	15.9	13.8	10.9	9.05	7.72	6.70	5.95	5.35	4.85	4.45	4.11		
	y				.0166	.0302	.0472	.0685	.0933	.155	.234	.326	.434	.558	.704	.860	1.03	1.22		
.059	P				36.5	28.4	23.3	19.8	17.1	13.5	11.1	9.56	8.35	7.37	6.63	6.01	5.50	5.08		
	y				.0147	.0268	.0426	.0620	.0853	.143	.212	.300	.403	.518	.649	.782	.955	1.13		
.063	P				45.3	34.9	28.6	24.1	20.9	16.6	13.6	11.6	10.1	9.02	8.10	7.33	6.71	6.20	5.75	
	y				.0131	.0241	.0385	.0565	.0778	.131	.198	.278	.372	.482	.603	.737	.887	1.05	1.23	
.067	P				54.8	42.1	34.7	29.3	25.2	19.9	16.4	14.1	12.2	10.8	9.70	8.82	8.06	7.45	6.90	6.45
	y				.0117	.0218	.0354	.0519	.0715	.121	.183	.258	.347	.447	.557	.686	.828	.985	1.15	1.32
.071	P					50.6	41.1	34.5	30.2	23.7	19.7	16.7	14.6	12.9	11.6	10.5	9.58	8.87	8.22	7.66
	y					.0197	.0319	.047	.0659	.111	.170	.241	.325	.411	.524	.645	.775	.922	1.07	1.24
.074	P					57.4	46.8	39.7	34.2	27.1	22.3	18.9	16.5	14.7	13.2	11.9	10.9	10.0	9.33	8.68
	y					.0183	.0302	.0446	.0621	.106	.161	.229	.307	.398	.503	.610	.739	.876	1.03	1.19
.078	P					68.0	55.5	46.8	40.3	31.8	26.0	22.3	19.4	17.2	15.4	14.0	12.7	11.7	10.9	10.2
	y					.0166	.0275	.0414	.0576	.0987	.150	.214	.289	.375	.471	.579	.696	.825	.970	1.12
.082	P					80.2	64.7	54.8	47.0	37.1	30.4	26.0	22.5	20.0	18.0	16.3	14.8	13.6	12.7	11.8
	y					.0152	.0252	.0382	.0535	.0925	.141	.202	.272	.353	.444	.548	.656	.780	.915	1.06
.086	P						75.5	63.3	54.9	42.9	35.1	29.9	26.0	23.1	20.8	18.7	17.2	15.7	14.7	13.8
	y						.0231	.0354	.050	.086	.132	.190	.256	.332	.420	.515	.624	.740	.870	.989
.090	P						83.5	70.3	60.8	47.5	39.2	33.2	28.8	25.7	23.2	21.9	19.1	17.6	16.2	15.0
	y						.0212	.0326	.0462	.0808	.124	.178	.241	.314	.397	.490	.592	.702	.825	.946
.106	P							122.	104.	81.2	66.8	57.0	49.2	43.4	38.9	35.4	32.5	29.9	27.6	25.7
	y							.0246	.0356	.0630	.0987	.143	.196	.255	.324	.402	.487	.582	.681	.790
.121	P								159.	121.	101.	85.5	73.5	65.3	58.0	52.9	48.4	44.4	41.1	38.4
	y								.0283	.0516	.082	.120	.164	.217	.273	.342	.415	.494	.582	.677
.135	P								224.	174.	141.	120.	103.	91.0	81.7	73.6	66.7	62.0	57.5	53.6
	y								.0230	.0431	.0695	.102	.141	.187	.239	.297	.367	.434	.510	.596
.148	P									231.	188.	159.	137.	121.	108.	98.	88.7	81.5	75.5	70.8
	y									.0367	.060	.0891	.124	.165	.212	.264	.320	.385	.455	.534
.162	P									309.	249.	211.	183.	160.	142.	128.	117.	107.	100.	92.5
	y									.0311	.0517	.0778	.110	.145	.186	.235	.285	.342	.405	.473
.177	P										330.	266.	240.	210.	187.	168.	154.	141.	131.	121.
	y										.0442	.0368	.0955	.127	.165	.208	.255	.307	.364	.425
.207	P													343.	303.	275.	250.	228.	211.	196.
	y													.101	.132	.167	.206	.247	.296	.347
.225	P														394.	355.	321.	297.	271.	252.
	y														.116	.147	.183	.223	.264	.311
.263	P															572.	520.	477.	437.	410.
	y															.115	.145	.177	.212	.233
.283	P																553.	600.	550.	513.
	y																.129	.153	.190	.226
.307	P																	780.	709.	660.
	y																	.140	.169	.201
.331	P																		897.	833.
	y																		.150	.180
.363	P																			1110.
	y																			.154
.394	P																			
	y																			
.430	P																			
	y																			
.460	P																			
	y																			
.500	P																			
	y																			

Stress of 100,000 lb./sq. in. is used for convenience. For any other stress τ, values of P (load in lb.) and y (deflection per turn) should be multiplied by $\tau/100{,}000$. Deflections are based on a torsion modulus $G=11.4\times10^6$ lb./sq. in. For any other value of G, deflections given should be multiplied by the ratio $11{,}400{,}000/G$.

modulus of the spring material.

Using the value of P given by Equation 4 in Equation 5, the deflection per turn then would become

$$y = \frac{4\pi r^2 \tau_m}{GdK_s} \quad \ldots\ldots (6)$$

Values of load P and deflection per turn y as calculated from Equations 4 and 6 for various outside coil diameters and various wire sizes are given in the table. These tables are based on an arbitrarily chosen stress of 100,000 pounds per square inch and a torsion modulus G of 11.4 $\times$ 10^6 pounds per square inch. The wire diameters listed are those of the music wire gage for sizes up to .09-inch and of the National Wire Gage for sizes from .106 to ½-inch.

Although stresses of 100,000 pounds per square inch, figured in this way, may actually be employed in many applications, it should be noted that this figure is used merely for convenience and is not necessarily the recommended working stress.

For static loading the working stress calculated may be taken equal to the yield point in torsion divided by the factor of safety. For any working stress other than 100,000 pounds per square inch, the loads and deflections given may be reduced in proportion. Thus for a working stress of 80,000, 80 per cent of the values given in the tables may be used. Also if the spring material has a modulus G other than 11.4 $\times$ 10^6 pounds per square inch, values of deflection per turn as given should be multiplied by 11,400,000/G.

2-1/4	2-1/2	2-3/4	3	3-1/2	4	4-1/2	5	5-1/2	6
11.3 1.48									
12.6 1.40									
21.2 1.15	19.1 1.46	17.3 1.78							
31.7 1.00	28.5 1.25	25.9 1.53	23.8 1.85						
44.4 .890	39.5 1.11	35.9 1.36	32.9 1.63						
59.1 .797	52.5 1.00	47.5 1.22	43.5 1.47						
77.2 .715	69.0 .903	62.5 1.11	57.1 1.33						
101. .642	90.5 .811	81.8 .995	74.8 1.20						
161. .525	145. .670	130. .829	121. 1.01	103. 1.41					
208. .475	187. .600	170. .746	154. .905	132. 1.27	114. 1.69				
335. .386	300. .492	270. .610	249. .748	211. 1.05	184. 1.41	164. 1.83			
422. .351	375. .447	339. .556	311. .680	266. .962	232. 1.30	204. 1.67	183. 2.10		
543. .313	483. .401	434. .501	396. .611	339. .870	296. 1.17	262. 1.52	236. 1.93	212. 2.36	193. 2.82
682. .282	608. .364	547. .454	498. .557	426. .793	370. 1.07	329. 1.39	294. 1.75	268. 2.16	244. 2.60
908. .246	811. .320	730. .402	668. .494	563. .702	487. .950	436. 1.24	390. 1.57	356. 1.94	323. 2.34
1170. .218	1040. .282	938. .358	858. .442	724. .631	630. .859	558. 1.12	499. 1.42	453. 1.76	416. 2.13
1530. .189	1370. .249	1230. .315	1115. .391	950. .565	824. .768	725. 1.00	652. 1.28	591. 1.58	540. 1.92
	1690. .224	1510. .286	1380. .354	1170. .515	1010. .700	892. .922	797. 1.17	725. 1.45	663. 1.77
	2170. .196	1960. .251	1780. .311	1510. .456	1310. .630	1150. .827	1030. 1.05	930. 1.31	854. 1.59

Illustrates Use of Table

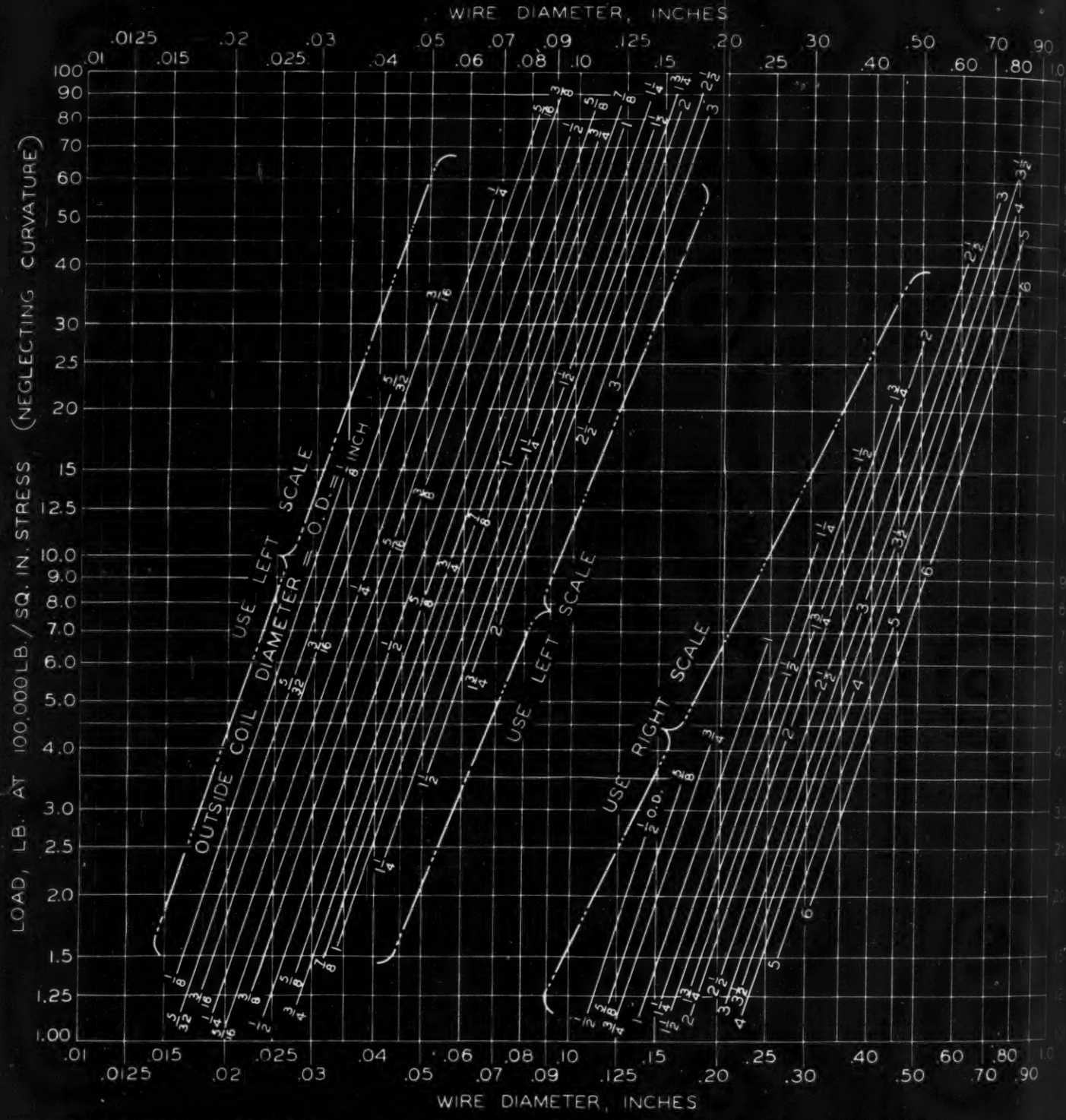
To illustrate the use of the tables, a spring of music wire may be selected with an outside diameter equal to 1 inch and a wire diameter of .135-inch. Music wire in this size has a yield point in torsion of about 120,000 pounds per square inch. Assuming a factor of safety of 1.5 on the yield point, the working stress would be 120,000 /1.5 = 80,000 pounds per square inch. From the table for this size of spring at a stress of 100,000 the load is 103 pounds and the deflection per turn .141-inch. At a stress of 80,000, the allowable load would be .8(103) = 82.4 pounds and the deflection per turn .8(.141) = .113-inch. If there are five active turns, the total deflection would be .565-inch at 82.4 pounds load.

To facilitate computation for intermediate outside diameter and wire sizes not listed in the tables, the charts of *Figs.* 1 and 2 have been prepared. As in the case of the tables these charts are based on a torsion stress of 100,000 and a torsion modulus of 11.4 $\times$ 10^6 pounds per square inch. In *Fig.* 1 the load at 100,000 pounds per square inch (calculated from Equation 4) is plotted against wire size, for various outside coil diameters. Thus for a wire size of .106-inch and an outside coil diameter of 1¼-inch the load at 100,000 pounds per square inch stress is 39 pounds.

Effect of Curvature Neglected

In *Fig.* 2 values of deflection per turn are plotted against wire diameter for various outside coil diameters. For example, with a wire size of .106-inch and an outside coil diameter of 1¼-inch, the deflection per turn at 100,000 pounds per square inch stress becomes .32-inch. It should be noted that, because of the interpolation necessary in reading these charts, a small error will usually be involved. Although this error in general will be less than two per cent, for best accuracy the values given in the table should be used if possible, or calculation should be made using Equations 4 and 6. However, the results obtained by using the charts of *Figs.* 1 and 2 are sufficiently accurate for almost all practical purposes.

It should be emphasized that the tables and charts given in this article should only be used for statically loaded springs. Where fatigue or repeated loading is involved, such as is the case



Based on a stress of 100,000 lb./sq. in. This may be too high for some materials or applications. To find any other stress τ, loads given must be multiplied by $\tau/100{,}000$

Fig. 1—Chart for calculating loads in statically-loaded helical springs

in automotive valve springs, stress concentration effects due to wire curvature cannot be neglected. For such cases the charts given in the writer's article on designing springs[2] or the spring tables[3] given by J. I. Hommel may be used. These charts and tables take into account the stress augment due to curvature and therefore show considerably lower values of load and deflection per turn for springs of small index than those given in the charts and tables of the present article. For large index springs, however, these differences will be small because the effect of curvature in such springs is small.

[2] "General Considerations in Designing Mechanical Springs—Part II", MACHINE DESIGN, February, 1938.

[3] "Machinery Data Sheets", Page 424a, *Machinery*, February, 1938.

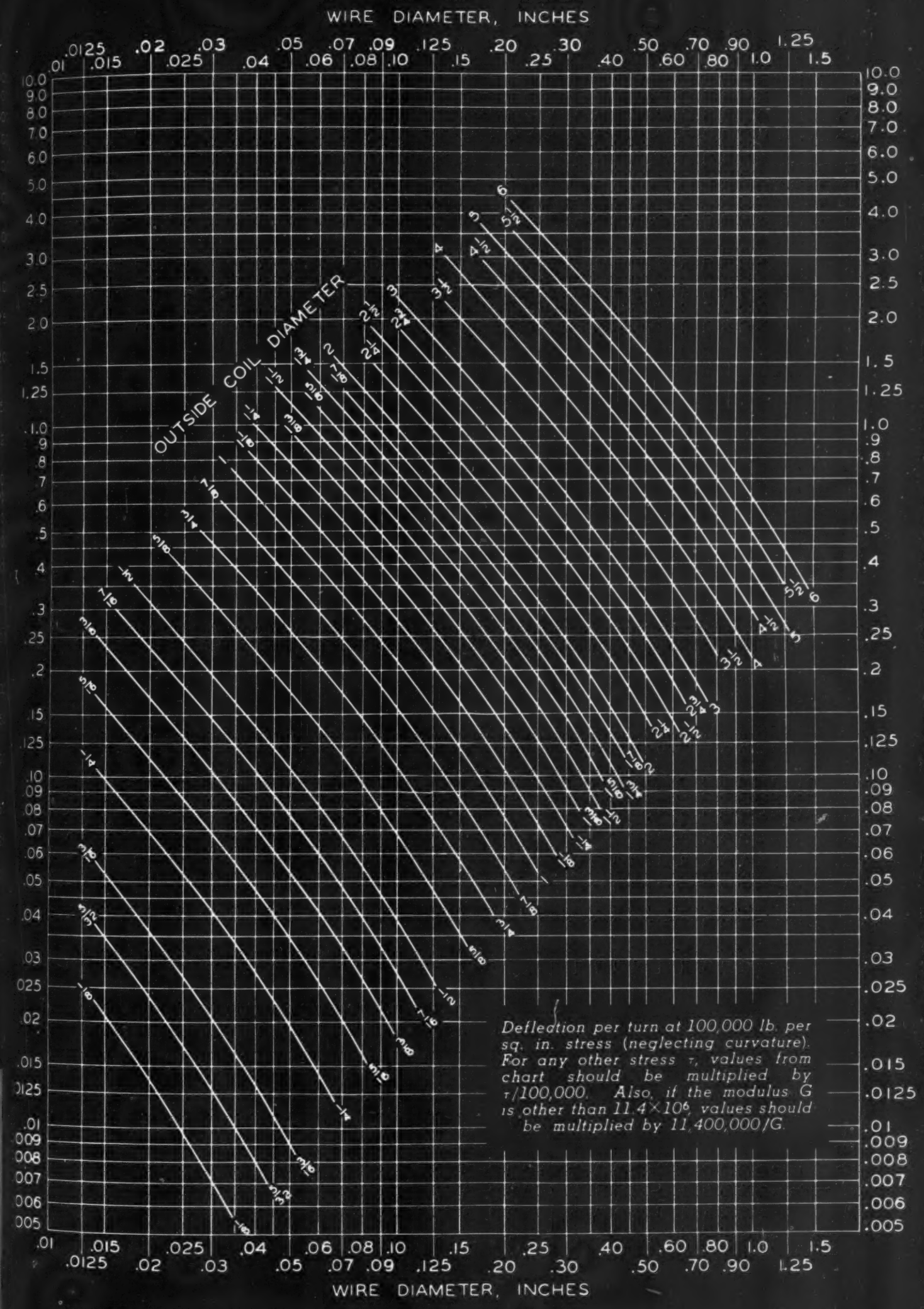


Fig. 2— Chart for calculating deflections in statically-loaded helical springs of round wire

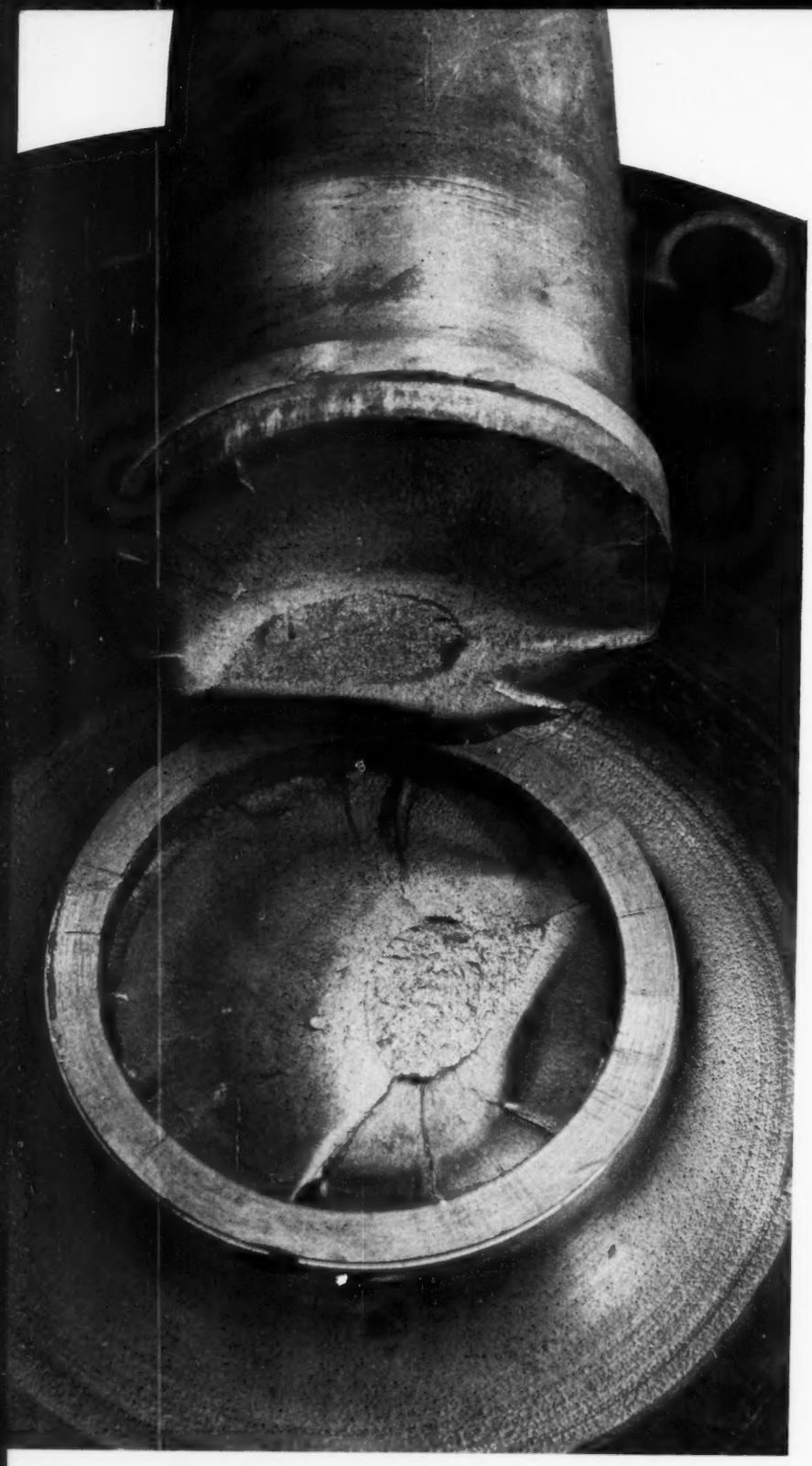


Fig. 9—Typical fatigue failure of shaft with shrink-fit hub

By Joseph Marin
Pennsylvania State College

Designing Shrink-Fit Assemblies

Part II

IN SOME of the machine assemblies cited in the introduction to this article in the previous issue, stresses due to twisting and bending moments as well as axial loadings may be present. Reference has been made to limiting values of these forces based on the holding abilities of the shrink-fit assembly.[6] Another factor that should be considered, however, is the influence of the combined stresses on the required diameter of the shaft or axle. The stresses produced in this more general case are represented in *Fig.* 10. Considering the inner unit or shaft, the stresses shown in *Fig.* 10 are:

S_c = the circumferential stress due to the inertia forces and shrink-fit pressure, as given by S_1 in Equation *g*

S_2 = the radial stress due to the inertia forces and shrink-fit pressure, as given by S_2 in Equation *g*

S_s = the shear stress due to the twisting moment T

S_L = the axial stress due to the bending moment M and axial load P.

The values of the stresses S_s and S_L for an element at a distance r are

$$S_s = \frac{Tr}{J} \qquad \ldots\ldots (p)$$

$$S_L = \pm\frac{Mr}{I} \pm \frac{P}{A_r} \qquad \ldots\ldots (q)$$

where J is the polar moment of inertia of

[6] This problem is discussed by O. J. Horger and C. W. Nelson, "Design of Press and Shrink-Fitted Assemblies", *Transactions*, A.S.M.E., Vol. 59, 1937, A.P.M., Pages 183-187.

the cross secton, I is the moment of inertia of the cross section, and A_r is the area of the cross section.

The triaxial principal stresses can be expressed in terms of the above stress components. One of these stresses is S_2 while the other principal stresses S_1 and S_3 can be expressed in terms of S_c, S_s and S_L. Their values are

$$\left.\begin{matrix} S_1 \\ S_3 \end{matrix}\right\} = \frac{S_L+S_c}{2} \pm \sqrt{\left(\frac{S_L-S_c}{2}\right)^2+S_s^2} \quad \ldots\ldots\ldots\ldots\ldots (r)$$

For three-dimensional stresses the strain-energy theory of failure is recommended for design when ductile materials are used. To use this theory the strain energy for an element at a distance r, *Fig.* 10, must be evaluated. In terms of the principal stresses this energy is

$$U=\frac{1}{2E}[S_1^2+S_2^2+S_3^2-2m(S_1S_2+S_2S_3+S_1S_3)] \quad \ldots\ldots (s)$$

The procedure to be used for obtaining the required

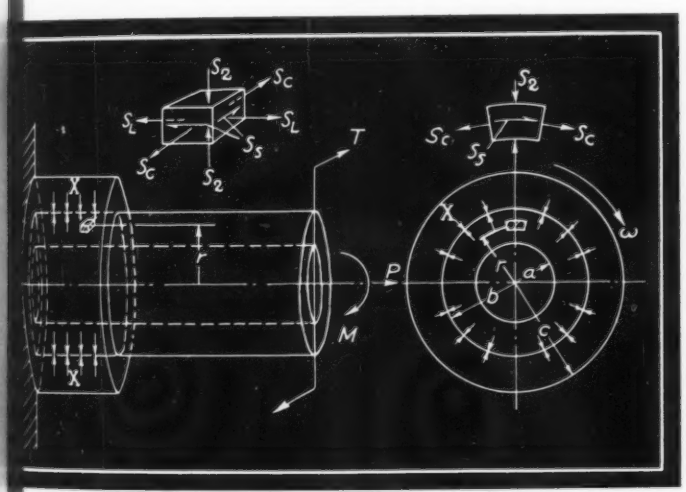


Fig. 10—Combined stresses from twisting, bending and axial loading as well as fit are shown for element in shaft with a shrink-fit hub

shaft diameter using Equation s is as follows:

1. Substitute values of the stress components from Equations g, p and q in Equations r to obtain the principal stresses S_1 and S_3
2. Place the values of the stresses S_1, S_2 and S_3 in Equation 3 to obtain an expression for the strain energy for an element at a radius r in terms of the loads and dimensions
3. Determine the value of r for which the strain energy is maximum
4. With the value of r found in Item 3, calculate the value of the maximum strain energy
5. Equate the maximum strain energy to the allowable value, $S_w^2/2E$. This equation will give the required shaft diameter in terms of the loads and working stress S_w.

The above method will be illustrated for particular cases of the loadings shown in *Fig.* 10.

Example 3—*Shaft Subjected to Shrink-fit Pressure, Bending and Twisting Moments*—For assemblies in which the speed is low, the inertia stresses can be neglected. The stress components due to bending and twisting moments and shrink-fit pressures then become

$$\left.\begin{matrix} S_2=-A\left(1+\frac{a^2}{r^2}\right), \quad S_c=-A\left(1-\frac{a}{r^2}\right) \\ S_s=\frac{Tr}{J}, \; S_L=\pm\frac{Mr}{I} \end{matrix}\right\} \quad \ldots\ldots (t)$$

Substituting the values of these stresses in Equations r, the principal stresses S_1 and S_3 can be determined. Placing these stress values S_1 and S_3, as well as S_2, in Equation s, the strain energy becomes

$$U=\frac{1}{2E}\left[2(1-m)A^2+2A^2(1+m)\left(\frac{a^4}{r^4}\right)\mp 2\frac{MAr}{I}+\frac{r^2}{I^2}\left(M^2+T^2\frac{1+m}{2}\right)\right] \quad \ldots\ldots (u)$$

By a comparison of the magnitudes of the terms in Equation u, the plus sign before expression $2MAr/I$ need be considered only, since this will give the maximum value of U. By calculus, the maximum value of U is for $dU/dr=0$, or

$$-8A^2(1+m)\frac{a^4}{r^5}+\frac{2r}{I^2}\left(M^2+T^2\frac{1+m}{2}\right)=0$$

or the distance from the axis at which U is a maxi-

Fig. 11—Below—Appearance of failure after hub has been removed

—Photos Courtesy Timken Roller Bearing Co.

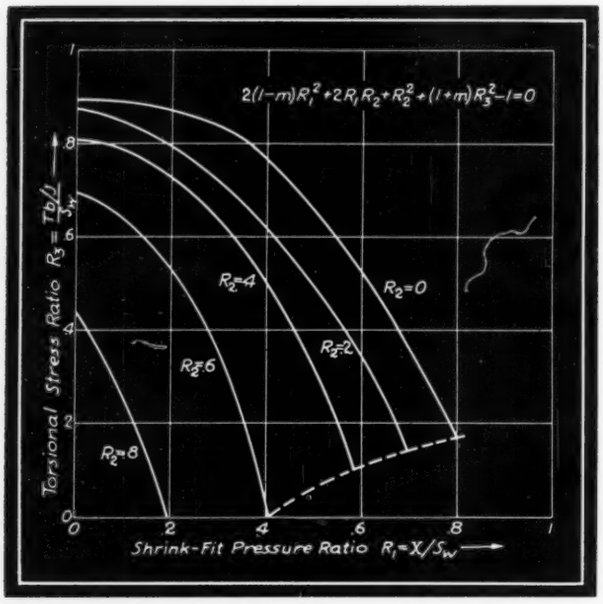


Fig. 12—Allowable twisting moment ratio for values of shrink-fit pressure ratio and bending stress ratios

mum becomes

$$r=\sqrt[6]{\frac{4A^2I^2a^4(1+m)}{M^2+T^2\frac{1+m}{2}}} \quad \ldots\ldots (v)$$

This value of r can be used in Equation u to find the critical or maximum value of U.

Considering the case of a *solid shaft*, $a=0$ and $A=X$ in Equation u, the strain energy simplifies to

$$U=\frac{1}{2E}\left[2(1-m)X^2+\frac{2MXr}{I}+\frac{r^2}{I^2}\left(M^2+T^2\frac{1+m}{2}\right)\right] \quad \ldots\ldots (w)$$

By inspection of Equation w, the maximum value of U is for the maximum value of r, or for $r=b$. That is,

$$U_{max}=\frac{1}{2E}\left[2(1-m)X^2+\frac{2MXb}{I}+\frac{b^2}{I^2}\left(M^2+T^2\frac{1+m}{2}\right)\right] \quad \ldots\ldots (x)$$

Equating U_{max} to the allowable value $S_w^2/2E$, the relationship between the allowable loads can be simplified to

$$2(1-m)R_1^2+2R_1R_2+R_2^2+(1+m)R_3^2-1=0 \quad \ldots\ldots (10)$$

where $R_1=X/S_w$=the shrink-fit pressure ratio, $R_2=(Mb/I)/S_w$= the bending stress ratio and $R_3=(Tb/J)/S_w$=the torsional stress ratio.

For a value of Poisson's ratio $m=.25$, Equation 10 becomes

$$1.5R_1^2+2R_1R_2+R_2^2+1.25R_3^2-1=0 \quad \ldots\ldots (10a)$$

The relationship between the allowable loads as given by Equation 10 can be represented graphically by plotting the value of R_2 for different possible ratios of R_1 and R_3. It is apparent from the expression for R_1, R_2 and R_3 that these ratios cannot exceed 1 and in some cases they are appreciably less. By expressing the design relation as in Equation 10, all possible combinations of loads can be considered. A plot of Equation 10*a* is shown in *Fig.* 12, in which the variation in the allowable twisting moment ratio R_3 is given for different values of shrink-fit ratio R_1 and for various possible values of the bending moment ratio.

For a solid shaft with shrink-fit pressure and bending without torsion, Equation 10 can be used for determining the allowable bending moment. For this special case, $R_3=0$ in Equation 10 and

$$R_2=\sqrt{1+2mR_1^2-R_1^2}\ -R_1 \quad \ldots\ldots (11)$$

The variation in the allowable bending moment for different values of the shrink-fit pressure is given by Equation 11 and is shown graphically in *Fig.* 13. That is, the ordinates to the curves are proportional to the allowable moments for a given value of the coordinate R_1 which is proportional to the shrink-fit pressure. This graph can also be used for determining the required shaft diameter by noting that ordinate R_2 multiplied by S_w/M equals b/I. Knowing $b/I=4/\pi b^3$, the radius b and hence the required diameter is evaluated.

To Determine Allowable Torque

For a solid shaft with shrink-fit pressure and a twisting moment T, Equation 10 can be used for determining the allowable twisting moment when the diameter is known or the required diameter when the twisting moment is known. To do this M or $R_2=0$ in Equation 10 and the shrink-fit pressure ratio R_1 in terms of the twisting moment ratio R_3 is

$$R_1=\sqrt{\frac{1}{2(1-m)}-\frac{(1+m)}{2(1-m)}R_3^2} \quad \ldots\ldots (12)$$

The variation between R_1 and R_3 as given by Equation 12 is represented in *Fig.* 14 for values of $m=.25$ and .35. For purposes of design the graph can be used for the selection of the allowable moment or for determining the required shaft diameter in a manner similar to that explained in the foregoing example of shrink-fit pressure combined with bending.

Example 4—*Shrink-fit Pressure and Axial Loading*—For shrink-fit assemblies in which the axial load is appreciable, the stresses produced by this

load must be considered in addition to the shrink-fit stresses. The resultant stress components are then the principal stresses and their values are the following:

$$\left.\begin{aligned} S_2 &= -A\left(1+\frac{a^2}{r^2}\right) \\ S_1 = S_c &= -A\left(1-\frac{a^2}{r^2}\right) \\ S_3 = S_L &= \pm\frac{P}{A_r} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (y)$$

Placing the values of these stresses in Equation *s* the strain energy for an element at a distance r from the center of the shaft is

$$U=\frac{1}{2E}\left[2A^2(1-m)+2X^2(1+m)\left(\frac{a^4}{r^4}\right)+ \ldots\ldots (B)\right.$$

$$\left.\frac{P^2}{A_r^2}\mp\frac{2PXA}{A_r}\right] \ldots\ldots\ldots\ldots\ldots\ldots (z)$$

The maximum value of U is, by inspection, of Equation z, for a value of $r=a$. Equating this value to the allowable magnitude of $U=S_w^2/2E$, an equation is obtained for determining the required shaft diameter or the allowable axial load. That is, from Equation z, by placing $U=S_w^2/2E$ and $r=a$, the relation between the shrink-fit pressure ratio R_1 and axial load ratio R_4 is

$$R_1=\frac{(1-r_a^2)}{2}\sqrt{1-\frac{15}{16}R_4^2} \quad \ldots\ldots\ldots (13)$$

where $R_4=P/Ar/S_w$=the axial stress ratio, $R_1=X/S_w$=the shrink-fit pressure ratio and $r_a=a/b=$ the dimension ratio.

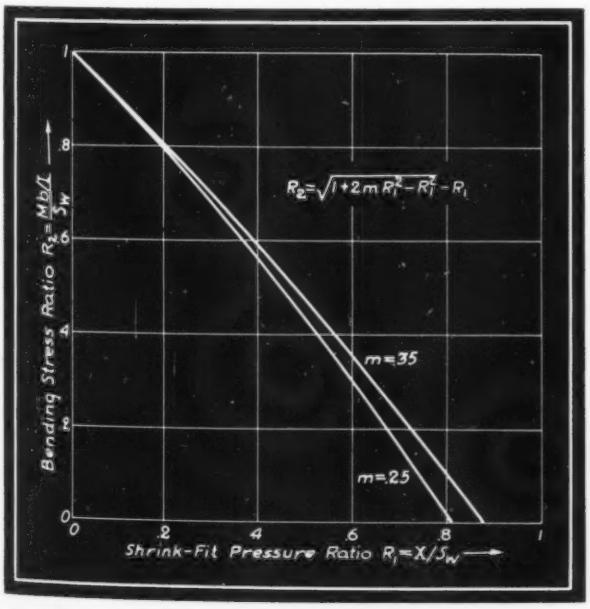


Fig. 13—Ratios for bending stress plotted against shrink-fit pressure ratios, Poisson's ratio is .35 or .25

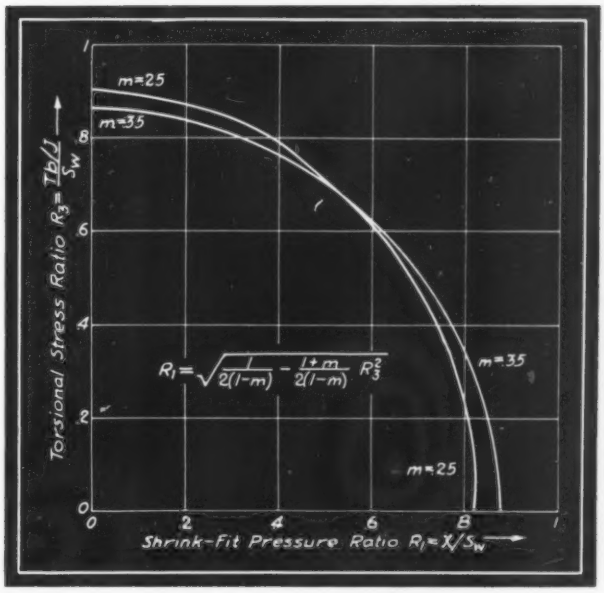


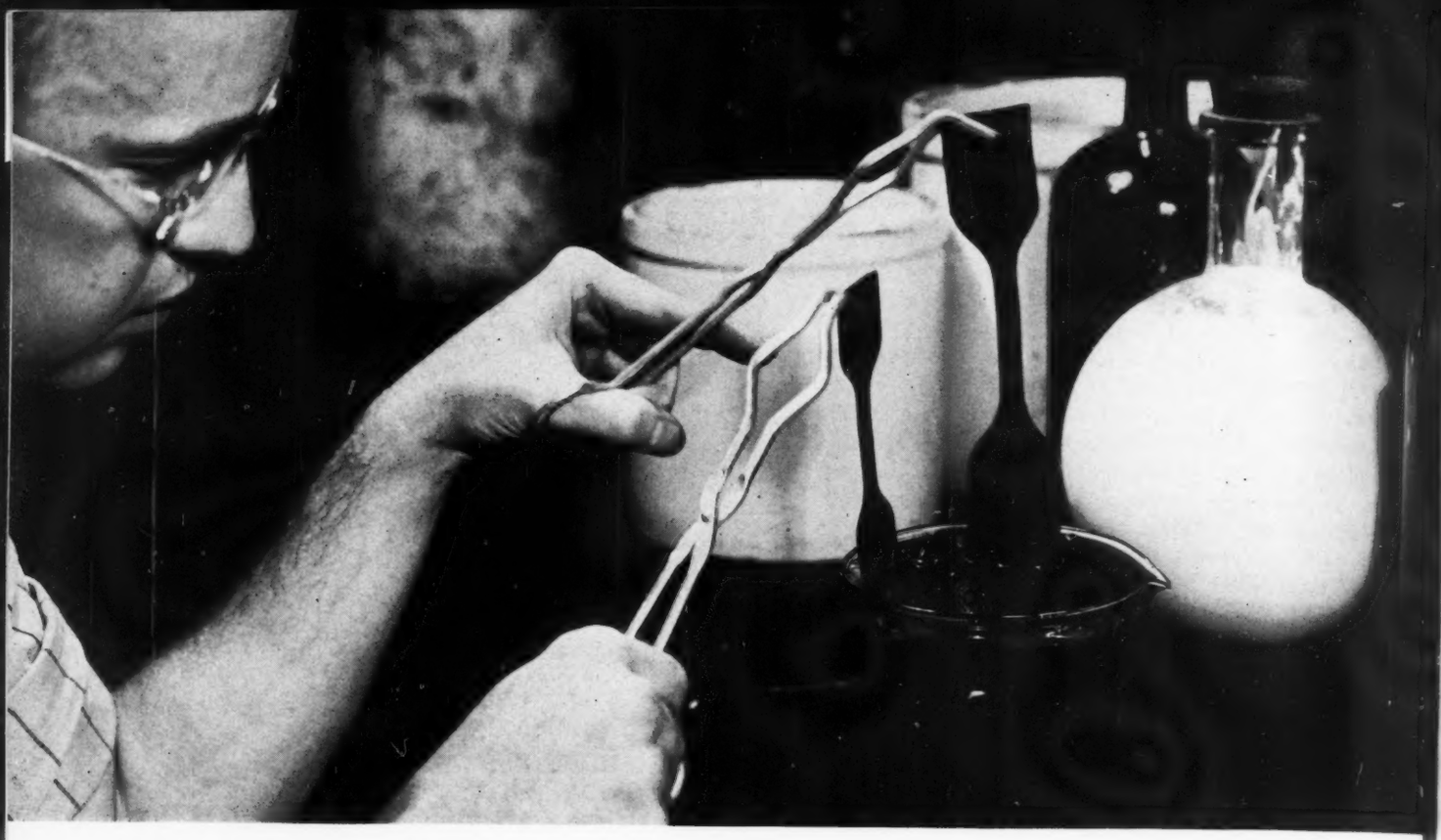
Fig. 14—Torsional stress ratios against those for shrink-fit pressure when Poisson's ratio is .35 or .25

It can be seen that Equation 13 can be used for determining the required radius b for particular values of the axial load and shrink-fit pressure. Inversely, this equation can also be used for finding the allowable axial load for a shaft of particular dimensions and with a known value of shrink-fit pressure.

It should be emphasized that this article reviews only several factors that must be considered in the design of press and shrink-fit assemblies. The main part of the article has dealt with the influence of combined stresses in determining the allowable loads or required shaft diameters. This question has not been adequately considered in other studies of this problem. An attempt has also been made to present design graphs for simplifying the selection of required shaft diameters or for determining allowable loads. In using these results the designer should consider also the other factors that influence this problem.

For cases where fluctuating or fatigue stresses are present, the foregoing discussions must be modified to include the effects of this type of loading. This will be done in the next issue and design charts will be included to assist in quickly selecting the proper dimensions or allowable loads. A theory for considering combined fatigue stress will be presented and several types of assemblies under various kinds of loads will be discussed.

Reproductions of the cover design used on this issue are available to readers upon request. Printed by the four-color process on enameled white stock, the reproductions are protected by a synthetic varnish coating.



How Synthetic Rubbe

By Otis D. Cole

Research Laboratory
The Firestone Tire & Rubber Co.

IN THE past few years the activity in rubber research laboratories all over the country has been increasing steadily and several materials have been developed which are approximately equal to natural rubber in most respects and for some purposes are better than the natural product. These materials are the result of systematic testing and selection of thousands of experimental materials in each class until only a few having the desired characteristics remain. Each of these was selected for commercial use because of certain outstanding characteristics which make it desirable. So far, the producers are to be commended for the relatively few materials which have been introduced to the industry. This fact is more readily appreciated when one considers that it is possible more or less to "tailor-make" a material for each special purpose.

There are numerous articles in the literature on the preparation and compounding of various types and varieties of synthetic rubbers and the characteristics of the products made from them. A comprehensive summary up to June, 1940, was given by Wood.†

It should be pointed out that the term "synthetic rubber" is actually a misnomer, because in order for the name to be correct the synthetic materials would have to be identical chemically with natural rubber, which is not the case. These products should more properly be called "synthetic rubber-like materials." However, because of common usage they will be referred to in this paper as synthetic rubbers.

In addition to the class of synthetic rubber-like materials, there are available other materials which have some rubber-like characteristics. In this group are found organic polysulfide polymers (Thiokol), Vinylite, plasticized Polyvinyl Chloride (Koroseal), polybutylene (Vistanex), etc. These materials are thermoplastic even when compounded with other materials, instead of thermosetting as in the case of compounded rubber. The plasticized Vinylites have some properties such as chemical inertness which make them more desirable in cases

* Abstract of paper presented in a Rubber and Plastics subdivision session at the recent American Society of Mechanical Engineers semiannual meeting in Cleveland.
† This and other contributions are listed at end of article.

where flexibility without resilience is required. The Thiokols or organic polysulfide polymers might be included among the synthetic rubbers but, although they appear to be vulcanizable, their thermoplasticity makes them useful only to a limited degree in service where elasticity and other rubber-like properties at elevated temperatures are desired. Thiokol is one of the oldest of the American types of synthetic materials having rubber-like properties. Its high resistance to oils, other solvents, and all kinds of aging, as well as its impermeability to gases makes it serve a useful purpose in industry.

Four Types Are Discussed

Materials considered as synthetic rubbers and covered in the following fall into four classes: Neoprene types, Buna S types, Buna N types, and Butyl rubber.

Neoprene types are polymers of chloroprene or copolymers of chloroprene with other materials. It is evident that there is possible a wide variety of products all made from the same basic materials. The term "neoprene", therefore, should not be considered as descriptive of a single product. Neoprenes as a class may be termed moderately oil-resisting rubbers.

Buna S types are copolymers of butadiene with styrene. A Buna S type of polymer has been adopted by the Rubber Reserve company for use in tires and as a general purpose rubber. Fundamentally, it is less efficient and develops lower physical properties at ordinary temperatures than natural rubber, but it is much more heat resistant and when properly compounded is practically as cold resistant as natural rubber. It is similar to natural rubber in that it is not oil resistant.

Buna N types are copolymers of butadiene and acrylonitrile. They are generally oil and hydrocarbon solvent-resistant to a high degree; however, they are poor in resistance to oxygenated solvents. Their cold resistance in general is poor but, by correct compounding, fair to good cold resistance can be obtained. A large number of different varieties of this type are on the market under the tradenames of Hycar O. R., Chemigum I, II, III and X, Perbunan, Buna NM, NX, NXM, NXX and NF, etc. These vary as to the ratios of the constituents and the method of preparation, but their properties as a class are similar.

Butyl rubber is reported to be a copolymer of isobutylene with butadiene. It is high in chemical stability, very impermeable to gases and is said to be heat resistant. It may eventually have the lowest cost of all the synthetic rubbers. In the near future a new plant will go into production and at that time sufficient material will be made available, so that a complete evaluation of all its properties in all types of products can be made.

It should be understood that the possibility of a new material being found which surpasses all the present ones now in production or development is not remote, but rather is likely. The following

be[illegible]eet Current Demand*

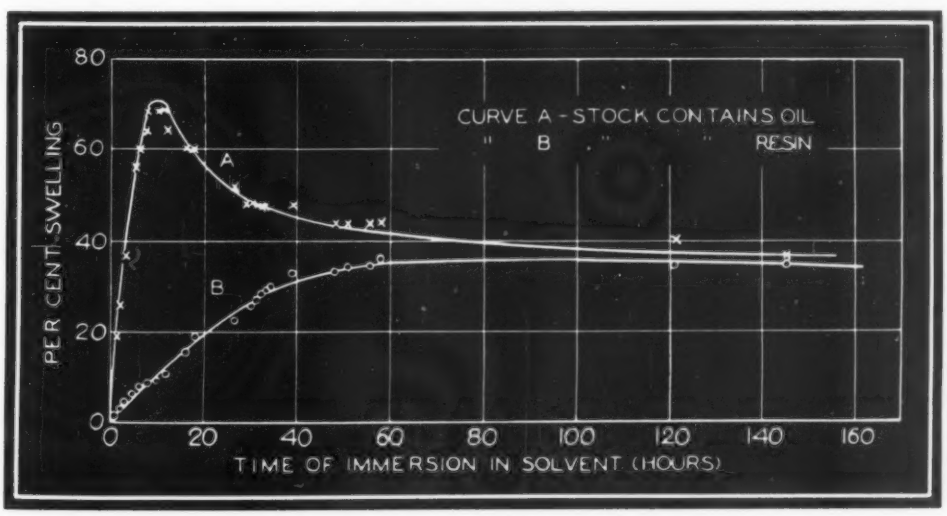


Fig. 1—Per cent swelling plotted against time of immersion in carbon tetrachloride for two Buna N type compounds

TABLE I

Tensile Data for Various Rubbers with Similar Compounding

Type of Rubber	Tensile Strength[1] (psi)			Stress at 400% Elongation (psi)			% Elongation at Break		
	Pure Gum	P-33* Black	Channel** Black	Pure Gum	P-33* Black	Channel** Black	Pure Gum	P-33* Black	Channel** Black
Natural	2500	....	4400	650	....	2100	800	....	600
Buna S	200	1200	3000	....	1100	1900	300	430	580
Buna NM	700	1400	2500	550	1025	1450	420	520	560
Buna NXM	800	1600	2700	550	1225	1750	480	500	550
Buna NF	450	800	1300	....	825	....	300	400	340
Neoprene	3900	....	3400	950 (600%)	....	2200	1020	....	550

[1]All stocks were cured to the "optimum cure" as judged by tensile strength. The tensile strengths of the various Buna N type stocks containing P-33 and channel black can be measurably increased or decreased by the use of different softeners.

*These stocks were compounded with softeners, vulcanizing ingredients, etc., and contained 100 parts of P-33 black per 100 parts of rubber or synthetic rubber

**These stocks contained softeners, vulcanizing ingredients and 50 parts of rubber grade channel black per 100 parts of rubber or synthetic rubber

examples of the more or less unusual properties of a few of the present materials are given with the foregoing in mind. New developments may greatly change the picture in the next few months.

When evaluating synthetic rubbers in the laboratory, it must be kept in mind that we are working with new, entirely different materials and not rubber. It is easy to make the mistake of attempting to interpret laboratory data on synthetic rubbers on the basis of experience with natural rubber, thus drawing erroneous conclusions.

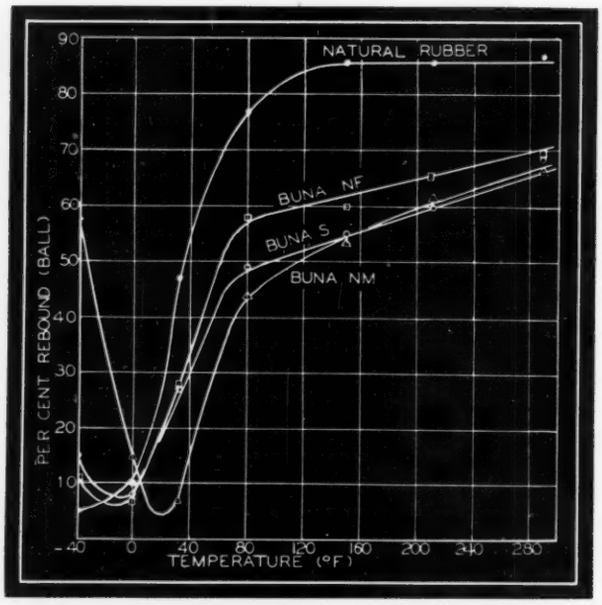


Fig. 2—Effect of temperature on rebound efficiency of pure gum stocks

Because of our present interest in the butadiene or Buna type synthetics, the majority of the examples will be chosen from that class. Each has been developed to fit a special need, such as ease of processing, ease of molding, oil resistance, cold resistance, etc.

Data given in TABLE I show that the tensile strengths of pure gum stocks prepared from the Buna type rubbers are very low. It is only after these rubbers have been compounded with carbon black that they exhibit tensile properties which remotely resemble those of natural rubber stocks. Even then the tensile strengths are far below those of natural rubber stocks having similar compounding. Neoprene is different in this respect, for the pure gum stock has higher tensile strength than the stock compounded with channel black. It is evident that tensile strength is not the complete criterion for the judgment of quality of Buna type synthetic rubbers, because if it were, none of them would have been considered further as possible materials for replacement of natural rubber in tires, for example.

Tensile strengths of the various Buna N type synthetic rubbers show rather definite correlation with other physical properties such as oil resistance, cold resistance, etc., as will be shown later.

Resists Swelling in Oil

The fact that the Buna N types of synthetic rubber exhibit very low swelling when exposed to oils is one of the most unusual properties and, at the same time, the most important property of this group. As a class they are better than neoprene in this respect. The different Buna N types have oil resistances as shown in TABLE II. Resistance to swelling in oil may be controlled, more or less, by proper selection of Buna N type synthetic rubbers. The negative swelling, or shrinking, of the Buna NXM stock in SAE 10 oil is most probably due to the extraction of some of the plasticizer by the oil. This property is important and must be compensated for by proper compounding when shrinkage is not desirable. By correct compounding it is possible to produce a stock which will not change in volume when immersed in oil.

An interesting and rather unusual swelling phenomenon is illustrated by the following example: Two Buna NXM gasket compounds *A* and *B* were tested for resistance to swelling in carbon tetrachloride, which has a very pronounced swelling effect on all of the Buna N types. Compound *A* contained as the plasticizer an oil which was soluble, while compound *B* contained a resin which

was practically insoluble in carbon tetrachloride. The data for per cent swelling versus time of immersion for the two stocks are shown in *Fig.* 1. It is obvious that compound *A* would not be satisfactory as a gasket in contact with carbon tetrachloride. These two compounds in carbon tetrachloride are given as examples because the effect is exaggerated. However, our observations would indicate that this phenomenon is common, especially with aromatic solvents, and may be the cause of actual shrinkage in other oils. It is interesting to note that the usual three-day or seven-day immersion test would have rated these two compounds as equal in resistance to swelling. The method of Garvey (8)*, lends itself more readily to following changes in swelling during immersion than does the regular A.S.T.M. method (9).

The property of resilience is one which makes rubber an unusual material. In general, the Buna or Butadiene types of synthetic rubbers normally have lower resilience than does natural rubber, as shown in *Fig.* 2.

Compounding Increases Efficiency

Although the data shown in *Fig.* 2 would indicate that the Buna S type of synthetic rubber is normally less efficient than natural rubber, it does not follow that it cannot be compounded to produce highly efficient stocks. However, when a stock is compounded to produce equal efficiency the hardness is increased over that of natural rubber compound. *Fig.* 3 shows a comparison between a high efficiency rubber compound and a Buna S compound designed to have approximately the same efficiency. The hardness values at the various temperatures are included to illustrate this point.

A comparison of the rebound efficiency of typical natural rubber, neoprene GN and Buna S high channel black compounds is shown in *Fig.* 4. These curves corroborate other efficiency tests which show that Buna S has higher hysteresis loss than natural rubber and neoprene GN.

TABLE II

Per Cent Increase in Volume* After 24 Hours in Different Oils

Type of Rubber	Paraffin Base SAE 10 Oil	80% Kerosene 20% Benzene
Buna S	152	....
Buna NM	3	16
Buna NXM	—3	12
Buna NF	40	42
Neoprene GN	23	91

*Volume change determined by the method of Garvey (8).

Cold resistance, or the lack of it, in the oil-resistant synthetic rubbers is of utmost importance to those designing or specifying parts where these rubbers are to be used. The increase in resilience at low temperatures may be caused by changes in hardness, as is shown in *Fig.* 3. So far, no definite relationship between the shape of the resilience-temperature curve and the actual "brittle point" has been observed. It should be pointed out that the minimum point in the resilience-temperature curve does not mean that, at that temperature, the rubber is brittle and will break upon bending. There are some indications (See *Fig.* 3) that these minima mark the beginning of the definite stiffening or hardening which eventually renders the material unserviceable at lower temperatures.

In general, the cold resistance of the highly oil-resistant rubbers is poor—the more oil-resistant the rubber, the poorer the cold resistance. The data

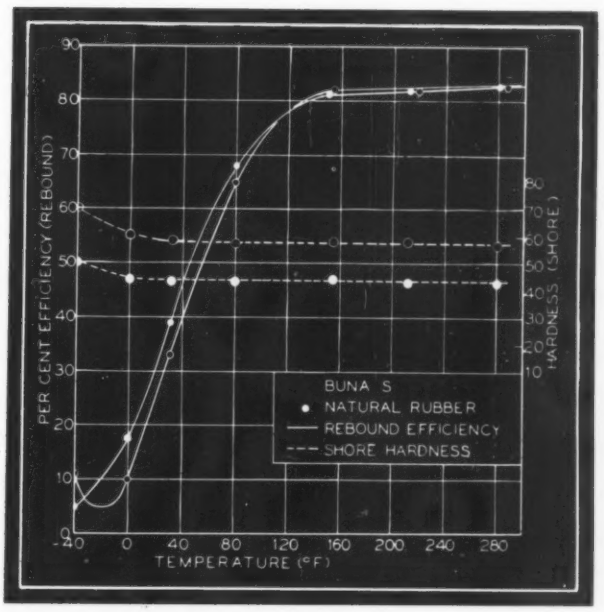


Fig. 3—Comparison of efficiency and hardness of natural rubber and specially compounded Buna S stocks

in TABLE III show the temperatures at which several Buna type and rubber compounds, varying only in the rubber used, become frozen or stiff to the touch. Refrigerated methyl alcohol was used as the coolant in this case. Values for the "brittle point" and "freezing point", taken from the literature (10), (11), are given for comparison. All comparisons of data should be made within one column of the tabulation, not between different columns.

In certain cases where rubber parts are to be used in contact with a solvent in service, the cold resistance tests should be made using the same solvent, refrigerated, as the coolant. For example, a fuel pump diaphragm compound when tested in air was frozen solid at −15 degrees Fahr., but when immersed in the fuel it was perfectly flexible at −50 degrees Fahr. because of the plasticizing action of the fuel.

The use of plasticizers plays an important part

*See references at end of article.

in the attainment of good cold resistance with the Buna N and neoprene types of synthetic rubbers. *Fig.* 5 shows the effect of various mixtures of two plasticizers *A* and *B* on the temperature at which several Buna NM and Buna NXM compounds ceased to become serviceable in air. It will be noted that Buna NM is more cold resistant in all cases than Buna NXM with the same plasticizer mixture present. It is possible to prepare compounds from Buna NF, treated with the proper plasticizer, which will be serviceable at temperatures as low as −70 degrees Fahr.

A very outstanding and rather unusual property of most of the synthetic rubbers, especially those

TABLE III

Stiffening, Freezing and Brittle Points

Type of Rubber	Stiffening Point (°F)	Brittle Point* (°F)	Freezing Point** (°F)
Natural	—48 to —52	—69.7	—86.8
Buna S	—36 to —40	—86.8 to —94	—86.8†
Buna NF	—40	.....	.....
Buna NM	—9	—51.7†	.....
Buna NXM	....	—14.8 to —18.4†	.....
Neoprene GN ...	—33	.....	.....

*See reference (10) **See reference (11)

†These stocks were undoubtedly prepared from different Buna type synthetic rubbers than those reported under "stiffening point."

TABLE IV

Thermal Decomposition Temperatures

Type of Rubber	Thermal Decomposition Temperature* (°C)
Natural	194-198
Buna NF	220-229
Buna NM	220-229
Buna NXM	205-212
Buna S	Above 249
Neoprene GN	239-249

*Temperature at which a rubber compound will decompose in one hour.

of the Buna and neoprene types, is their remarkable resistance to decomposition by heat. Thermal decomposition temperatures are shown in TABLE IV. The remarkably high heat resistance of Buna S as compared to natural rubber and the Buna N types would suggest its use for high temperature service where oil resistance is not a serious factor. Neoprene GN also shows superior heat resistance. However, all of the Buna and neoprene type synthetic rubbers become harder during continued exposure to high temperatures, but it is possible in some cases to plasticize them to overcome the hardening. This will tend to lower the heat resistance slightly.

Synthetic rubbers show exceedingly good resistance to all types of accelerated aging. A comparison of the aging characteristics of the various Buna types illustrated in TABLE I is given in TABLE V. Their resistance to heat (air bomb) is remarkable when it is remembered that similar natural rubber compounds are badly deteriorated after only ten hours under the same conditions. As the data for oxygen bomb aging indicate, the Buna N types show slightly less resistance to oxidation than to other types of aging. However, their relative deterioration is much less than that of rubber under the same conditions. Buna S shows some susceptibility to oxidation, but is affected much less than natural rubber.

TABLE V

Effect of Aging

Type of Rubber*	Per Cent of Original Values — Air Bomb[1] Tensile	Air Bomb[1] Elong.	Oxygen Bomb[2] Tensile	Oxygen Bomb[2] Elong.	Oven[3] Tensile	Oven[3] Elong.
Buna S	105	77	100	98	94	60
Buna NM ...	114	65	93	94	116	63
Buna NXM ..	112	64	103	94	118	68
Buna NF ...	151	70	106	83	150	73
Natural Rubber ...	...	..	56	..	91**	..

*Original values for these compounds are given under "P-33 Black" in Table I

**After only 14 days in oven

[1]Aged 15 hours in air bomb at 260 F, 80 psi pressure

[2]Aged 46 hours in oxygen bomb at 158 F, 300 psi pressure

[3]Aged 28 days in hot air oven at 158 F.

All the synthetic rubbers harden or become stiffer during heat aging treatments as illustrated by the elongation values in TABLE V. This fact must be considered when designs are being made for the use of these materials. All natural aging data which have been obtained up to this time indicate that the Buna type synthetic rubbers will be entirely satisfactory in this respect.

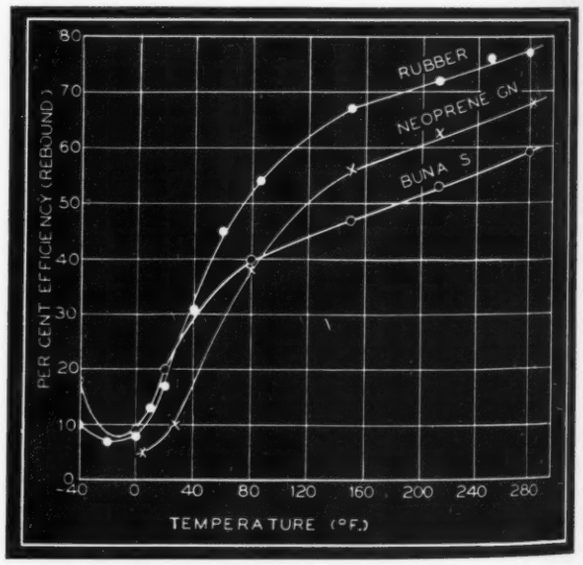


Fig. 4—Effect of temperature on rebound efficiency of compounds containing high channel black

Although no data for neoprene are given here, its high resistance to aging is well known. However, it stiffens during heating and aging to an equal if not greater degree than the Buna types.

Buna S types can be used in nearly all cases to replace natural rubber. Generally satisfactory service as compared to natural rubber has been ob-

served in the case of passenger tires. It must be pointed out that with this or any synthetic rubber, as in the case of any new material, certain difficulties are present and must be overcome. For example, truck and heavy-duty tires at present are the result of years of specialized engineering and design, based on the characteristics of natural rubber. In order to meet the service conditions encountered today, radical departure from present thinking and designs may have to be made in order to fit synthetic rubber into the picture. It is sufficient to say that the Buna S types appear to fit more nearly into the scheme of things as we see them today than any of the other synthetic rubbers.

Buna N types of synthetic rubbers are being recommended for all types of mechanical goods such as hose, packings, gaskets and rollers, wherever high resistance to aging, oils and hydrocarbon solvents is desired.

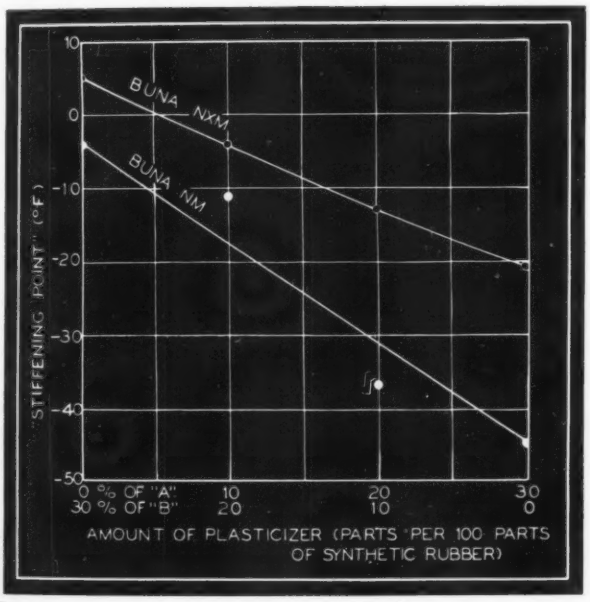


Fig. 5—Stiffening points of two Buna N type compounds for various mixtures with plasticizers A and B

Neoprene types are used wherever moderate oil resistance and good resistance to ozone and sunlight is desired. Since it will not support combustion it is widely used as a flameproof, oilproof, wire insulation.

Butyl rubber can best be utilized where its inherent properties of chemical stability, resistance to ozone, light and high permeability to gases can be used to best advantage. As has been pointed out, no entirely satisfactory tires have as yet been made from Butyl rubber.

Many of the really serious problems of today may be problems only because of the fact that certain handling processes designed for natural rubber are not fundamentally correct for the synthetic rubbers used. Because of this, it is possible that in the future the rubber industry will depend more than ever upon the mechanical engineer for the solution of its processing and handling problems.

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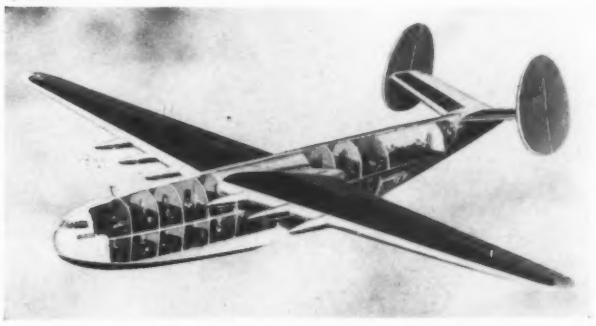
Designs Sky Leviathan

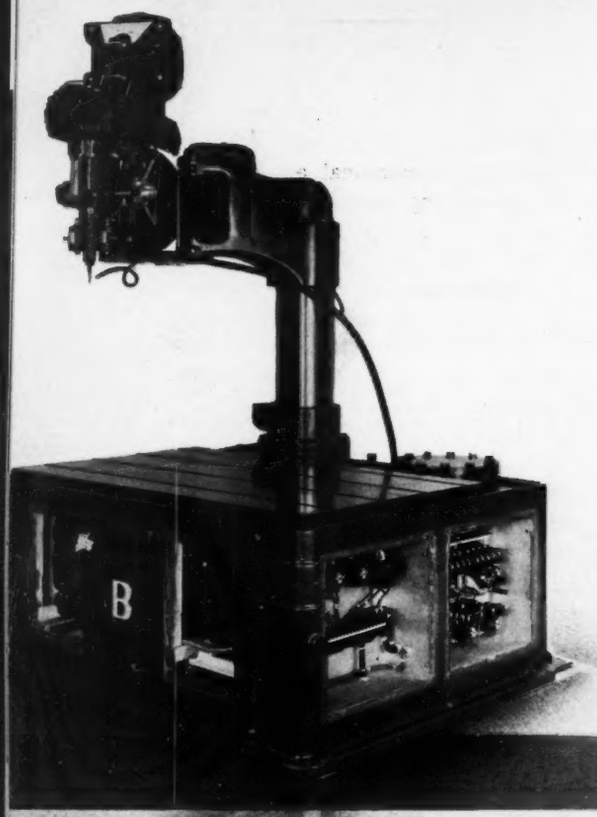
NO CRAZY dream is the sleek 250,000-pound flying ship shown. The Glenn L. Martin company is ready to translate this design at any time into an actual air vessel. As a commercial plane for which the design is drawn, the new ship will be able to carry 102 passengers, each with 80 pounds of baggage, together with 25,000 pounds of mail and cargo to London in 13 hours. In this service she would be able to rival, in a year of operation, the payload carrying capacity of a surface ship.

As a military transport the number of troops and heavy supplies that the ship could carry may



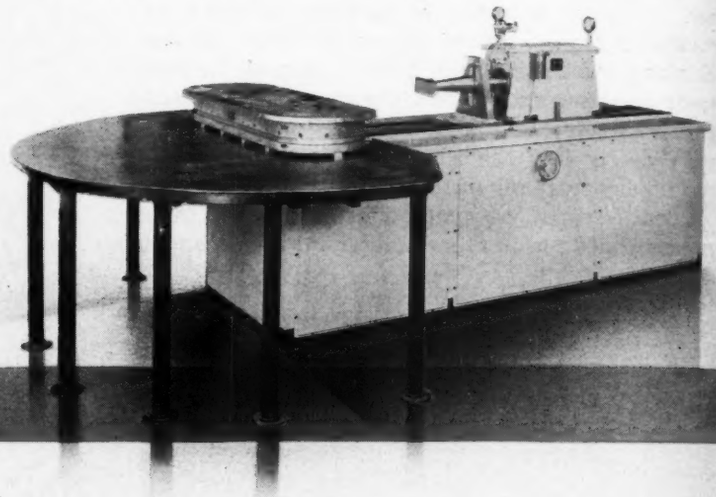
be gaged from the fact that the 140,000-pound Mars may carry 150 armed men and their equipment. Enormous size of the Mars is indicated by the fact that the space in her hull is equivalent to that in a fifteen-room house.

It was for the design of these two ships that Glenn L. Martin recently won the American Design Award. Mr. Martin, whose company built the China Clipper and her sisters as the first transocean commercial giants, declares that now the only limitation to the size of flying boats is commercial demand.



Above—Designed for high production, the Bakewell radial tapping machine eliminates the need for successive passes in cutting precision threads. Leading-on mechanism employs a lead screw with a hobbing section which is used to thread accurately the brass guide fingers for each new tapping job

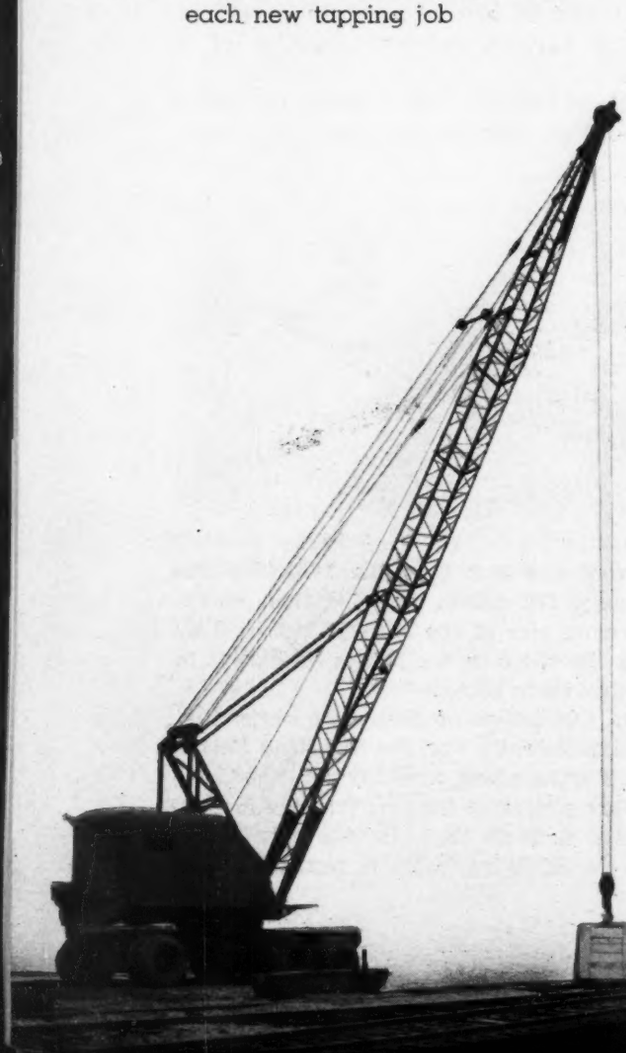
Below—Formation of straight extruded sections into any desired shape is accelerated by use of the Southern Engineering metal-forming machine. Variable speed reversing transmission system drives a movable head on which a die is bolted. One end of the section is attached to the movable die and is drawn between it and a mating die held against it by air pressure



Above [illegible] welder [illegible] stroke [illegible] Stroke [illegible] by the [illegible]

Machi[illegible] th[illegible]

(For [illegible], see Pag[illegible]



Left—Hoist, swing and travel motions are air-controlled in the 20-ton Osgood Mobilcrane. Brakes are air-operated and steering is hydraulic. Dual chain drive on the tandem wheels permits large vertical wheel displacements when operating on rough terrain

Below—Conservation of critical materials has received particular attention in the redesign of the portable Lectro-Shear. Previous model had an attached end handle which has now been eliminated by reducing the size of the field case and shaping it to form a self-handle

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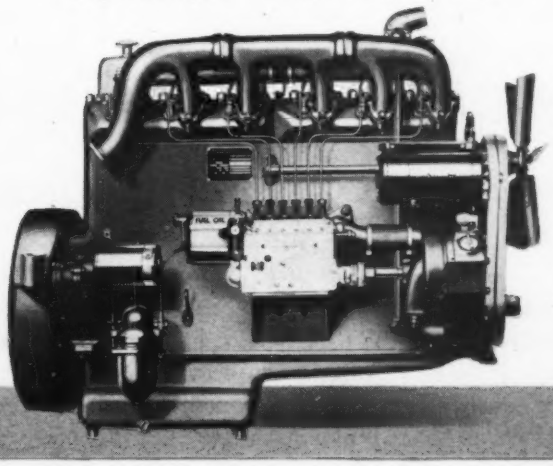
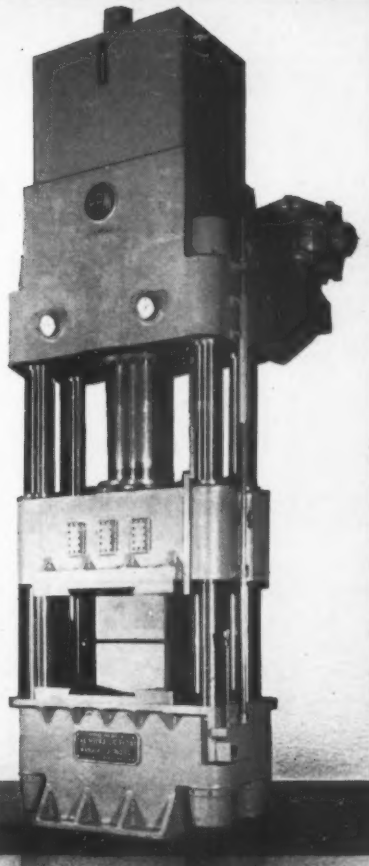
Below—Operating with a 6 to 1 compression ratio, the Waukesha multifuel engine burns any liquid fuel from furnace oil to gasoline. Cylinder injection and spark ignition are used for all fuels, only the injection timing and type of spark plug being changed when changing fuels





Above — ...g pressure in the Progressive seam welder ... through a double-acting adjustable-stroke ... mounted directly on the head support. Stroke ... and wear compensation are controlled by the ... a dummy piston in the machine head

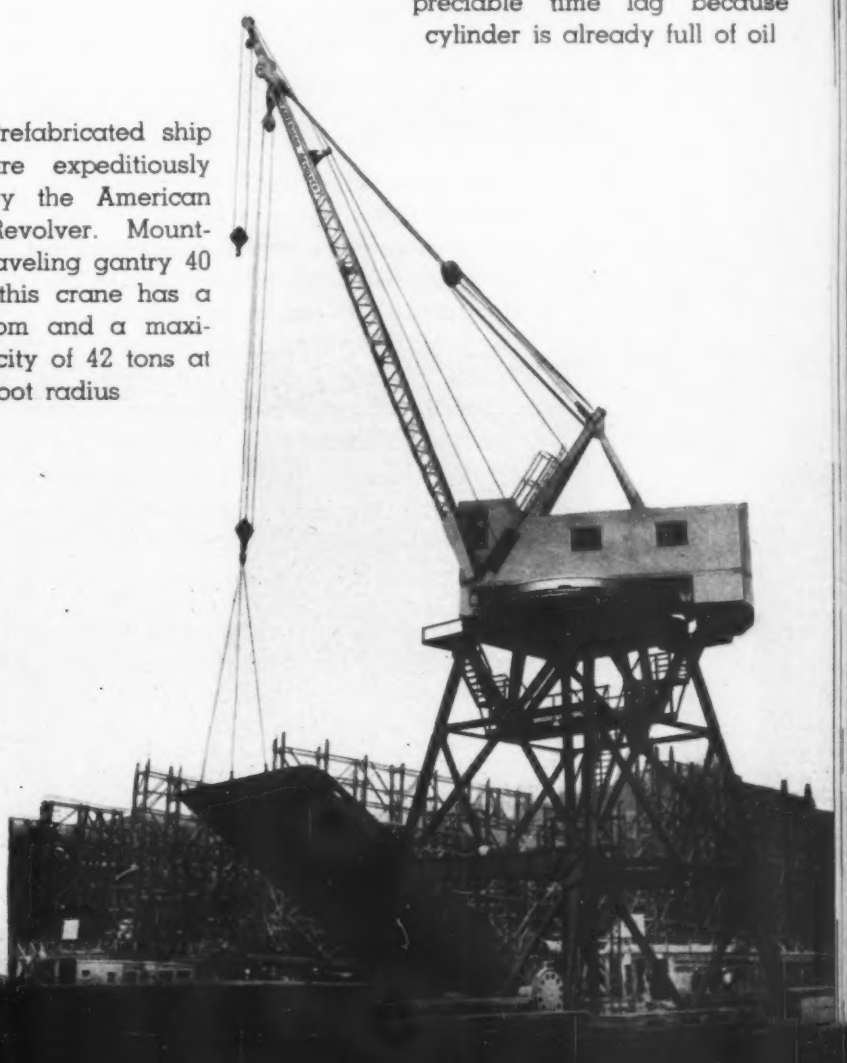
Above — Control of the HPM all-hydraulic fastraverse forging press is accomplished entirely by changing the stroke of the variable-delivery oil pressure pump. Press is closed rapidly by gravity, pressure stroke following at once without appreciable time lag because cylinder is already full of oil

his Behind the Guns

(For ... see Page 144)

... Designed for automatic operation the ... hydromatic shell-turning lathe has hy...lly-controlled feeds with infinite varia...tin drive motor is interlocked with the hy...eed mechanism and drives the backgear ... shaft through a silent chain

Right — Prefabricated ship sections are expeditiously handled by the American Shipyard Revolver. Mounted on a traveling gantry 40 feet high, this crane has a 95-foot boom and a maximum capacity of 42 tons at 48-foot radius



MACHINE DESIGN *Editorial*

Standard Parts Should Be Utilized To Speed Production Program

NEVER before has a greater need been apparent for a wise utilization of standard designs or for the employment of standard machine parts in design work. It is only by full appreciation of the fact that every special design or special part retards to some extent the all-out manufacturing program that expectations of surpassing the production of the axis nations can quickly be realized.

Much as we may dislike many of the methods of the Germans, the fact remains that rigid—even regimented—employment of standards helped them build the mightiest war machine thus far. For years before the war their program of simplification and standardization placed them on a basis which, though considered restrictive by some engineers, certainly put them far ahead of all other nations from a military standpoint.

Too great a tendency to adopt such a standardization policy in this country would, in times of peace, hinder progress and development. In war the situation changes, as proved by the strenuous efforts now being made by government bureaus and industry to clarify, simplify and standardize.

One of the most efficient measures thus far adopted, serving not only to effect standardization but also conservation, is the program outlined elsewhere in this issue covering the new national emergency steels. It is believed that practically every requirement filled by the previously available alloys can be adequately met by these new materials.

Numerous other instances could be cited, ranging all the way from collaboration between this country and Britain in the adoption of standards and standardized designs, to the limitations now being placed on manufacturers by the government regarding the filling of orders for nonstandard machine parts. Limitation order L-145 issued recently, for instance, provides that a producer of bearings may not accept orders for certain sizes of bearings unless he is an "authorized producer" of the size required.

It is clearly evident that in the aim of engineers to "out-design the Axis", one of the biggest factors in achieving the goal will be the utilization of the most readily available standard parts and materials. "Specials" should be held to an irreducible low.

L. E. Jermy

Designing Accelerated-Motion Cylindrical Cams

Part II

By Nelson K. Bennett Sr.

Known values:

b = Traverse in last division (Section 2)

D/n = Spacing of divisions

$$B = \tan^{-1}\frac{bn}{D} \qquad P = R\cos B$$

$$M_2 = R\sin B \qquad Q_2 = R - P$$

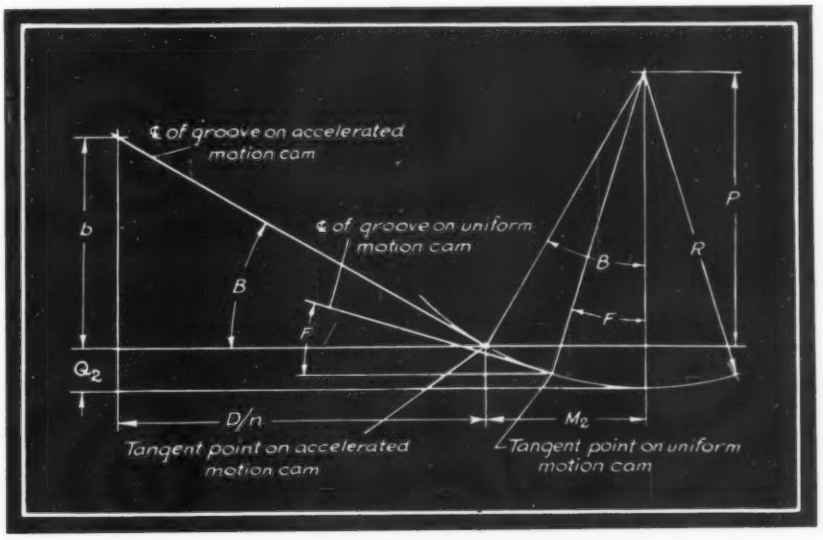


Fig. 4—Relocation of the tangent point for the last division is accomplished in a manner similar to that of Fig. 3

Known values:

T, S, D, $C/2$, a, a + d, a + 2d, etc., through b (Section 2)

Q_1, M_1 (Section 3)

Q_2, M_2 (Section 4)

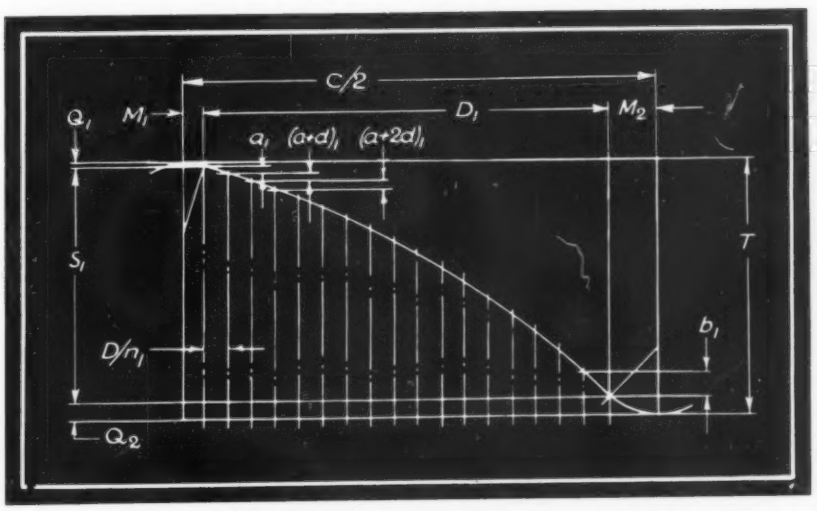


Fig. 5—Based upon the previous four sets of calculations, the formulas associated herewith result in the final determination of cam groove increments

$T_1 = S + Q_1 + Q_2$

$C_1/2 = D_1 + M_1 + M_2$

Compare value of T with value of T_1

Compare value of $C/2$ with value of $C_1/2$

Note whether original values of T and $C/2$ are increased or decreased

d_1 = difference in values of $C/2$ and $C_1/2$

When $C_1/2 > C/2$

$C/2 = M_1 + M' + (D - d_1)$

$\frac{D}{n_1} = \frac{D}{n} - \frac{d_1}{n}$

$D_1 = D - d_1$

When $C_1/2 < C/2$

$C/2 = M_1 + M_2 + (D + d_1)$

$\frac{D}{n_1} = \frac{D}{n} + \frac{d_1}{n}$

$D_1 = D + d_1$

d_2 = difference in values of T and T_1

d_2/n = revision of each increment

When $T_1 > T$

$a_1 = a - d_2/n$

$(a+d)_1 = a + d - d_2/n$

$(a+2d)_1 = a + 2d - d_2/n$

When $T_1 < T$

$a_1 = a + d_2/n$

$(a+d)_1 = a + d + d_2/n$

$(a+2d)_1 = a + 2d + d_2/n$

S_1 = sum of all revised increments

Proof: $T = S_1 + Q_1 + Q_2$

$C/2 = D_1 + M_1 + M_2$

Example Shows Accuracy of Method

Assume

6-inch diameter cam

16 per cent acceleration

$C = 18.85$ $r = .125$

$T = 6.00$ $R = .313$

$W = .375$ $A = T/2 - R = 2.69$

Then

$$B = tan^{-1}\frac{2.69}{18.85/4} = .570 = 29°41'46.75''$$

$$D = \frac{A}{sin\,B} = \frac{2.69}{.495} = 5.425$$

$$e = sin^{-1}\frac{.313}{5.425} = .058 = 3°18'9.35''$$

$$F = B + E = 32°59'56.1''$$

Let $n = 30$

$A\&B = R\ sin\ F = .545 \times .313 = .170$

$M\&N = R\ cos\ F = .839 \times .313 = .262$

$X = R - N$, $Y = R - M$ $\} = .313 - .262 = .051$

$$D = \frac{C}{2} - (A + B) = \frac{18.85}{2} - .170 \times 2 = 9.084$$

$$S = T - (X + Y) = 6.00 - .051 \times 2 = 5.90$$

$$W = \frac{n}{2}U + n = \left(\frac{30}{2}\right).16 + 30 = 32.40$$

$$a = \frac{S}{W} = \frac{5.90}{32.4} = .182$$

$$b = a(U+1) = .182(.16+1) = .211$$

$$d = \frac{b-a}{n-1} = \frac{.029}{29} = .001$$

$$D/n = \frac{9.08}{30} = .303$$

$$B = tan^{-1}\frac{a}{D/n} = tan^{-1}\frac{.182}{.303} = 31°1'1.81''$$

$M_1 = R\ sin\ B = .515 \times .313 = .161$

$P = R\ cos\ B = .857 \times .313 = .268$

$Q_1 = R - P = .313 - .268 = .045$

Similarly

$$B = tan^{-1}\frac{B}{D/n} = \frac{.211}{.303} = 34°53'41.19''$$

$M_2 = R\ sin\ B = .572 \times .313 = .179$

$P = R\ cos\ B = .820 \times .313 = .256$

$Q_2 = R - P = .313 - .256 = .056$

$T_1 = S + Q_1 + Q_2$

$S = 5.899175$

$Q_1 = .044682$

$Q_2 = .056186$

$6.000043 = T_1$

$6.000000 = T$

$.000043 = Difference$

$$\left(\frac{C}{2}\right)_1 = D + M_1 + M_2$$

$D = 9.0844$

$M_1 = .1610$

$M_2 = .1787$

$9.4242 = \left(\frac{C}{2}\right)_1$

$$\frac{C}{2} = 9.4248$$

$$\left(\frac{C}{2}\right)_1 = 9.4242$$

$.0006 = Difference$*

*Comparisons indicate the calculations to be nearly exact. Therefore, the increment values a, $a+d$, $a+2d$ and division spacing value D/n as found in connection with *Figs.* 2 and 3 are correct.

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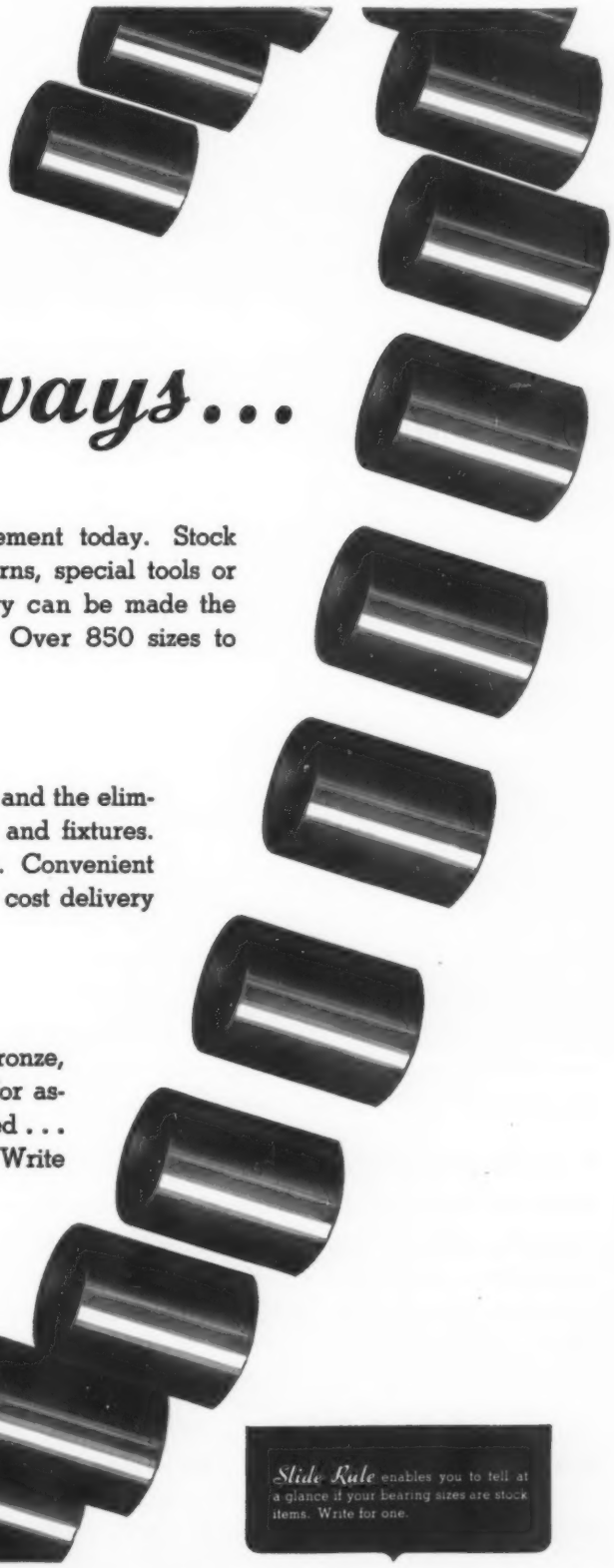

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Professional Viewpoints

" . . . will it pay for itself?"

To the Editor:

The latching system for the bottle-raising cylinders of a rotary bottle-filling machine, as described on Page 61 of MACHINE DESIGN for June, illustrates an important question which often appears under many disguises. Is it worthwhile to add mechanism to a machine for the sole purpose of reducing wear on the useful working parts? The answer is purely economic—will the added mechanism pay for itself? The writer has seen some machines in which a thousand dollars of mechanism had been added to save thirty dollars' worth of compressed air a year, or sixty dollars of additional annual maintenance. On the other hand, some machines have been observed in which excessive power cost and rapid wear were accepted in the name of "practical simplicity" and "fewer parts to get out of order."

The present bottle-filling machine cylinder-latching mechanism is a good example of the careful economic analysis required before adding nonfunctional mechanism. Estimating the cost of this latching mechanism, its value is about five hundred dollars. With steady-demand power at one cent per horsepower-hour, doubled to cover the cost of wear due to this excess power, we have forty-eight cents a day with which to pay for the latching mechanism. On the basis of twenty-four hours a day, three hundred days a year, this gives one hundred and fifty dollars a year. Thus the latching mechanism is a profitable investment on the basis of twenty-four hour operation, but would be uneconomical if the machine were used only eight hours a day.

All of this points to the conclusion that the value of mechanism added solely to reduce power consumption or wear is largely determined by the intensity of the machine use. The writer would be greatly interested in the comments of other readers on this question, and believes that the thoughts of the engineers who designed the described latching mechanism would be of special interest.

—R. E. BRUCKNER
Vineland, N. J.

" . . . is answer to design problems"

To the Editor:

Mr. Bruckner's reaction to my article is both logical and interesting. I, too, have seen many machines equipped with costly mechanisms designed primarily to save a few dollars on maintenance. In the development of the latching system for this filling machine, the answer to design problems was sought more than to maintenance. Nevertheless,

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the maintenance cost was substantially reduced. The latching system cost of only 250 dollars well justifies the design simplification.

Chief design problems solved by the latching system were: First, reduction in the objectionable lifting (about ¼-inch) of the rotating part of the machine due to the total compression load of the raising-cylinder springs acting through the raising arm (corresponding to a lever in which the power arm is three times the weight arm); second, minimization of the drag resulting in smoother starting; third, elimination of shock load and gear strains; and fourth, reduction in the size of the air clutch.

—J. KANTOR, *Chief Engineer*
The Liquid Carbonic Corp.

" . . . being requested for filing"

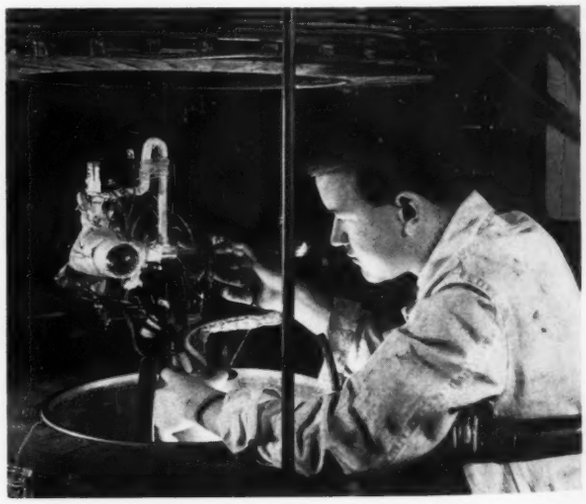
To the Editor:

Please forward tear sheets of the following articles which appeared in the June issue of MACHINE DESIGN: "Designing Shrink Fit Assemblies—Part I"; "Steel and Wood Replace Aluminum"; "Designing Accelerated-Motion Cylindrical Cams—Part I."

These articles are being requested for filing purposes, due to the overlapping of the articles.

—W. J. POTTHOFF
The Emerson Electric Mfg. Co.

Publication of articles to avoid overlapping is impossible due to the varying length of manuscripts. MACHINE DESIGN will, however, be glad to furnish tear sheets, whenever available, on request.—ED.



MASS spectrograph segregates gas molecules and their constituent atoms according to their masses. When hit by a "bombarding" electron the molecules acquire independent charges and are accelerated electrically into the semicircular evacuated tube. A slit at the end of the tube emits only ions of certain mass, the lighter or heavier ones losing their charge on hitting the platinum-coated walls of the glass tube. Spectrograph has 7000 feet of copper tubing wound about a copper shell. When 300 amperes flow in the tubing, a strong magnetic field is produced.

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Engineering Tools and Processes

By Furman C. Hesse, associate professor of engineering drawing and machine design, University of Virginia; published by D. Van Nostrand Co. Inc., New York; 627 pages, 6 by 9 inches, clothbound, available through MACHINE DESIGN *for* $4.50 *postpaid.*

In these days of materials substitutions and enforced recourse to alternative fabricating methods arising out of both material shortages and the inadequacy of certain manufacturing facilities, engineers and designers are finding it necessary to change over their designs from and to such processes as stamping, forging, casting, machining, etc. Some designers may have only a limited acquaintance with one or more of these processes and to such men this book will be of invaluable assistance.

Beginning with a survey of basic materials, elements and devices, each standard machine tool and each of the several methods of metalworking and woodworking are considered separately in the light of their effect on mechanical design of machine parts. Differences in design criteria from the standpoint of production economy, dimensional accuracy and feasibility of the process to be used are contrasted in detail with those for other possible processes. In acquainting the engineer with the possibilities and limitations of manufacturing methods, the book serves as a sound basis for successful design and detail procedure.

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Handbook of Mechanical Design

By George F. Nordenholt, Joseph Kerr and John Sasso; published by McGraw-Hill Book Co. Inc., New York; 277 pages, 8¼ by 10¾ inches, clothbound, available through MACHINE DESIGN *for* $4.00 *postpaid.*

Compiled from reference-book sheets and design standard sheets that have appeared in *Product Engineering,* this handbook is confined to practical design methods and procedures that have been in use in engineering design departments. As such it supplements the more theoretical treatments found in conventional handbooks and texts.

Subject matter is arranged under the following chapter headings: Charts and tables; materials; beams and structures; latches, locks and fastenings; springs; power transmission elements and mechanisms; drives and controls; design data on production methods.

More than five hundred illustrations are used to show a wide variety of machine parts and mechanisms, while much of the design information is in the form of tables and nomographic charts.

Metal facts... Organized

for Production Victories

American industry...in the rush of converting its plants to war production...needs much new information about alloys. Such information...detailing the selection, fabrication and uses of ferrous and non-ferrous Nickel alloys...is available promptly from our files of technical reports and shop guides.

And, as further support in the battle of production, we offer the assistance of our engineering staff and field service men. Their recent experiences in many plants, their practical knowledge of ways to overcome shortages of materials, makes them especially helpful during wartime.

Nickel...and information about Nickel ...goes wherever they best speed Victory.

Nickel

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

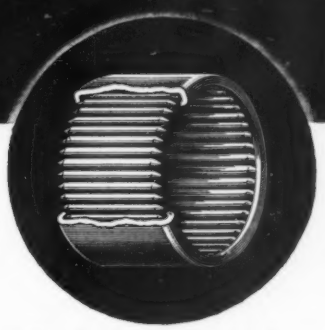
New PARTS AND MATERIALS

Small Precision Limit Switch

SPECIFICALLY designed for machine tools where space and operating force are limited, or as built-in contact mechanisms on other electrical devices, Class 9007 Type P small precision limit switches are now being offered by Square D Co., 4041 North Richards street, Milwaukee. Only 2 inches long by 1 inch square, the basic switch units are enclosed in transparent molded polystyrene cases sealed against tampering. Operating lever can be adjusted to any position in a complete circle.

To operate the switch, 15-degree travel is sufficient and an additional 40-degree emergency overtravel in either direction is permitted by lever. A camera shutter type toggle mechanism gives extremely accurate operation with only 2½ ounces force applied to a 1-inch lever arm. Dimensions of die-cast enclosures for surface mounting types are 3⅜ x 1 7/16 x 2 1/32-inch. A flush type arrangement is also available, permitting switch to be built into the machine casting. Push rod or roller arm actuators are used. Enclosed type switches require only five-degree rotation for operation and provide for 25 degrees emergency overtravel in

ONE SPECIFICATION THAT *HASN'T* CHANGED



HE used to design knitting machines; now he's working out the details of aircraft sub-assemblies Or perhaps he has "changed over" from blueprints of streamlined trains to medium tanks—and so it goes.

He was able to take conversion in stride because of his background, resourcefulness and adaptability to new problems and requirements. You'll find fresh evidence of this every day on assembly lines all over America.

The Torrington Needle Bearing, too, has "changed over"—and its adaptability is proving itself anew—in applications where its unique advantages mean more today than ever.

Its small size, for example, is saving space and critical materials. Its remarkable ease of installation is cutting assembly time . . . its low coefficient of friction, assuring smooth performance . . . its high capacity and efficient lubrication, reducing the need for replacement or maintenance attention—all are vital wartime features.

It is not surprising, then, that engineers and designers, in changing over to war production, have found the Needle Bearing to be one of the important specifications they haven't had to change.

***FOR INFORMATION** concerning capacities and sizes, send for Catalog No. 109. Or consult a Torrington engineer. He is an expert in adapting the Needle Bearing's advantages to specific problems.*

THE TORRINGTON COMPANY
TORRINGTON, CONN., U. S. A. • *Est. 1866*
Makers of Needle and Ball Bearings
New York Boston Philadelphia Detroit
Cleveland Seattle Chicago Los Angeles
San Francisco Toronto London, England

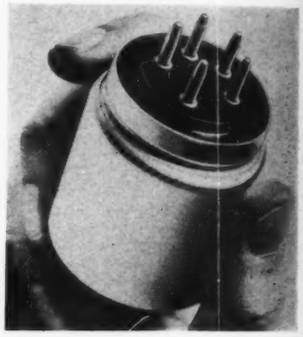
TORRINGTON NEEDLE BEARING

Every feature fills a wartime need

either direction. To reverse contact action or provide latch type operation, the return spring is readily shifted. Snap-action, silver contacts have both alternating and direct current ratings, high enough for direct control of small solenoids or contactors as large as the company's size IV. Normally open and normally closed circuits are insulated electrically to make unnecessary a common connection between them.

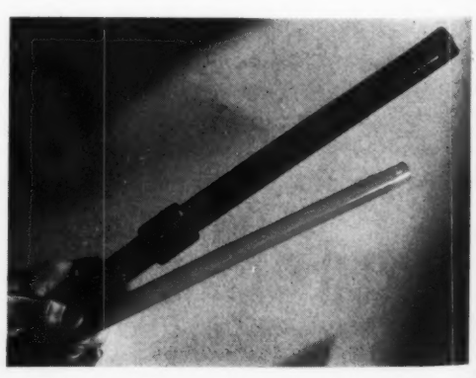
Sensitive D-C Aircraft Relay

DESIGNED for use in vacuum tube output circuits where little power is available, a new sensitive direct-current relay for aircraft service has been brought out by the industrial control division of General Electric Co. Small and light, weighing only 3¼ ounces, the relay has a sealed aluminum cover for protection from dust and against damage from rough handling. Designed to meet all Air Corps requirements set up for devices of this type, it has a maximum continuous current rating of 2 amperes at 32 volts, and a maximum make or break rating of 10 amperes. Coil is rated at 32 milliwatts minimum and 1 watt maximum. Maximum coil resistance is 3000 ohms. Contacts provide single-pole, double-throw operation. The relay is known as CR-2791-C100C.



Large Transparent Tubing Offered

ILLUSTRATED below are two sizes of Saran tubing offered by The Dow Chemical Co., Midland, Mich.—one a ¾-inch inside pipe size and the other ¾-inch outside diameter transparent tubing. Saran tubing was placed on the market some time ago (see M.D. January, 1942.) The ¾-inch transparent tubing, the largest yet fabricated, can be used for oil lines for motors having central oil systems, gasoline lines for automobiles, tubing for record-

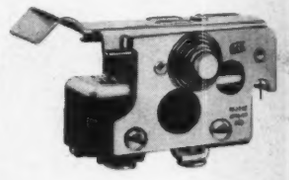



HAND FINISHING A ZINC ALLOY DIE
ZINC IN WAR
SPEEDING PLANE PRODUCTION
Sand cast dies of zinc alloy are used for stamping many sheet metal aircraft parts. This procedure saves time and money over the practice of machining dies from tool steel. Thus zinc is playing an important role in helping the aircraft industry to meet the demand of our fighting forces for "More Planes—Sooner"
Dies of unalloyed zinc were used in the days of limited aircraft production. But larger production has proved that a zinc alloy, originally developed for the die casting industry by this Company, and known as Zamak, provides additional advantages in the production of stamping dies.
The physical advantages of Zamak alloy dies include greater strength and hardness, less warpage, smoother surfaces and increased wear resistance. All of these factors contribute to longer production life, thereby cutting down the number of dies to be made—and fewer dies mean faster production.
This is just another instance of a peace-time development of zinc being turned to effective use in the War Production Program. It is also one more reason why civilian users of zinc may not be able to obtain all of the zinc products they would like to have.
THE NEW JERSEY ZINC COMPANY
MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS
9 STAMPING DIES
GALVAN-IZING
1 HULL PLATES
2 RUBBER
3 PAINT
4 BRASS
5 CERAMICS
6 DIE CASTING
7 PHARMA-CEUTICALS
8 METAL SPRAYING
FOR VICTORY BUY UNITED STATES WAR SAVINGS BONDS STAMPS
THE MAKING OF THE DIES
DETERMINING FURTHER FINISHING REQUIRED

ing devices and gages, refrigerant transfer, electrical insulation, humidifier supply lines, etc. Because of its toughness Saran has displaced such strategic materials as copper, nickel, stainless steel and ceramics in several fields. The tubing is available in sizes from ⅛-inch to ¾-inch outside diameter, with wall thicknesses of .062-inch to .3-inch.

Aircraft Switch Actuator

INTENDED for use in the throttle mechanism of an airplane, but with potentialities of wider application, a new switch actuator is announced by Micro Switch Corp., Freeport, Ill. A positive means of circuit closure, plus a manual release feature for automatically resetting switch for the next cycle of operation, are provided in the switch. This small sized, lightweight actuator accepts the company's Type R31 switch, Army Air Corps approved and replaceable in the field, and is considered part of the aircraft. No deviation permit is required for use of the actuator for aircraft. Supplied as a single unit, or in gang assemblies of 2, 3 or 4 units, left or right-hand, spaced to meet requirements, the actuator with the Type R31 switch permits elimination of a number of special relays and associated circuits now used in throttle-warning applications.

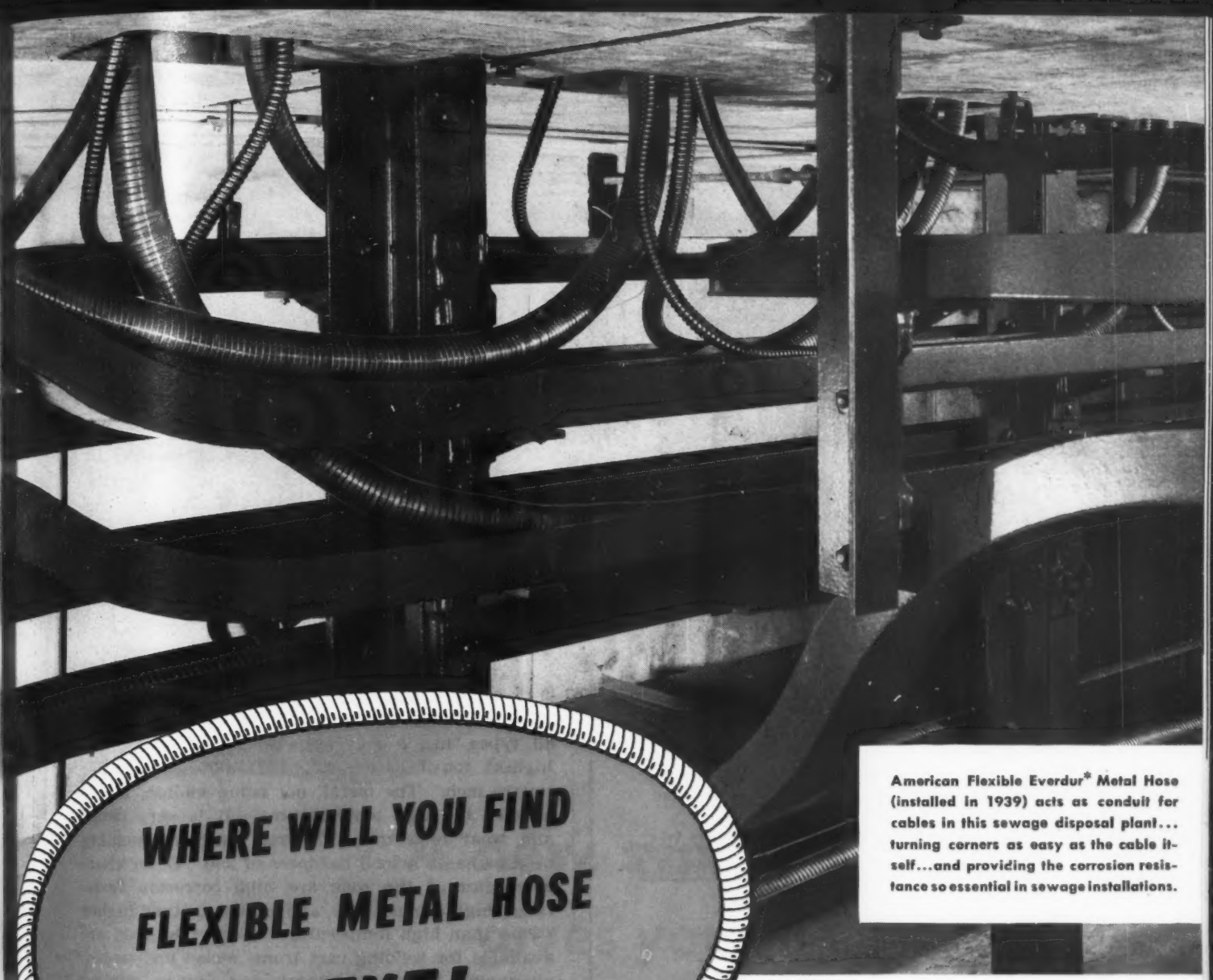


Hydraulic Pump Uses Plastics

DESIGNED for easy disassembling, the new auxiliary hydraulic hand pump announced by Bendix Aviation Ltd., North Hollywood, Calif., incorporates plastic parts which release vital metal for other war needs. In this pump plastic is used in both the check valves and in the piston head and piston rod bearing, substituting for bronze. The pump comprises a single-piston double-acting arrangement with an integral suction check valve mounted at right angles to the main bore. A chrome-plated steel piston rod fitted with plastic bearings and synthetic seals reciprocates within the aluminum alloy housing. Completing a life test of 110,000 cycles the pump is now being specified for Air Corps equipment.

Revolving Joint Eliminates Clamp

NOW being put on the market by Barco Manufacturing Co., 1801 Winnemac avenue, Chicago, is a new type of revolving joint capable of handling steam, air, oil, gas, water, and other fluids. The two ball seats of the joint permit a slight flexing angle to relieve strain on piping due to pulling together nipples and unions. The joint is also equipped with a ball race arranged so that the sleeve has a slight tendency to move in and



American Flexible Everdur* Metal Hose (installed in 1939) acts as conduit for cables in this sewage disposal plant... turning corners as easy as the cable itself...and providing the corrosion resistance so essential in sewage installations.

WHERE WILL YOU FIND FLEXIBLE METAL HOSE NEXT!

Instead of carrying oil, steam, gas or water, it "convoys" an electrical cable through the corrosion laden sub-level of a large sewage disposal plant.

Perhaps the most intriguing angle of flexible metal hose and tubing is its seemingly endless range of application—an unusual adaptability traceable to the variety of constructions in which we have made the product available. Using practically any workable metal, we can build flexible metal hose or tubing for anything from a simple oil can spout to a high pressure, *seamless* hydraulic line that can be flexed millions of times without breaking—a line that will give you the flexibility of garden hose, the dependability of metal, and the *strength of rigid pipe!* • Could some type of this hose or tubing be the "missing link" you have been looking for? Whether you need a flexible connector for misaligned or moving parts, for isolating vibration, for conveying air, water, oil, steam or fuel, you'll likely find we have a type of flexible metal hose or tubing that will do the job more capably. 42187

*Trademark, Reg. U. S. Pat. Off.

Practically all of our production is going to fill high priority orders, and our ability to deliver is, of course, limited accordingly...Meanwhile, do you have these fact-laden publications?

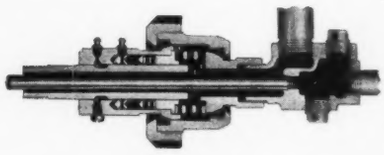
American Metal Hose

ANACONDA

AMERICAN METAL HOSE BRANCH of THE AMERICAN BRASS COMPANY • General Offices: Waterbury, Conn.

Subsidiary of Anaconda Copper Mining Company In Canada: • Anaconda American Brass Ltd., New Toronto, Ontario

out for expansion of the steam-heated and cooling rolls. In this joint, type 7 RB-8CRB, the clamp previously used with the company's revolving joints has been eliminated. The chevron



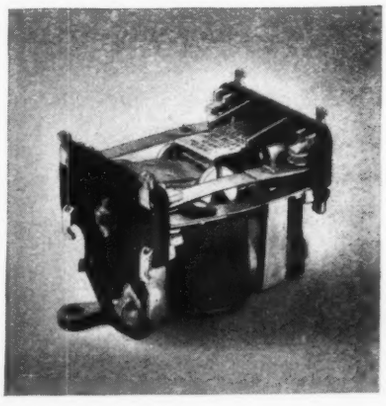
pack seal is maintained by constant pressure of a spring against the packing. Without removing the threaded sleeve from the roll the joint can be repacked when necessary.

Low Temperature Welding Rods

Developed by Eutectic Welding Alloys Inc., 40 Worth street, New York, new low-temperature, high strength welding rods are for use in aircraft, arms, and on various ordnance materials. No. 16, available in several grades for steel welding of all types, has a low temperature combined with highest tensile strength of 117,000 pounds per square inch. The metal, not being molten, is not affected by high temperatures. It is very dense and wear resistant. The rod used for welding bronzes has a brinell hardness of 290. Other characteristics of the rods are high corrosion resistance, high conductivity, and ability to stand higher strain than high temperature welds. The rods are available for welding cast irons, nickel and monel, aluminum, bronze and steel, and can be applied by conventional methods such as gas torch, furnaces, carbon and metallic arcs.

Lightweight Aircraft Relay

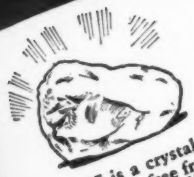
TO ITS line of control devices of aircraft applications General Electric Co., Schenectady, N. Y., has added a new four-pole relay, designated as CR2791-G100K. The relay is light in weight and has a maximum continuous current rating of



10 amperes at 12 or 24 volts direct current, and a maximum make-or-break current rating of 50 amperes at 12 or 24 volts direct current. Normally

MINERAL OIL. Most tracing papers are treated with some kind of oil. Mineral oil is physically unstable, tends to "drift", never dries completely. Papers treated with mineral oil pick up dust, lose transparency with age.

VEGETABLE OIL, chemically unstable, oxidizes easily. Papers treated with vegetable oil become rancid and brittle, turn yellow and opaque with age.



ALBANITE is a crystal-clear synthetic solid, free from oil and wax, physically and chemically inert. Because of this new stabilized transparentizing agent Albanene is unaffected by harsh climates —will not oxidize with age, become brittle or lose transparency.

A new synthetic solid gives you this *permanent* tracing paper

A remarkable new transparentizing agent developed in the K&E laboratories—produces this truly permanent tracing paper! ALBANENE is made of 100% long fiber pure white rags—treated with *Albanite*—a new crystal clear synthetic solid, physically and chemically inert. ALBANENE will not oxidize, become brittle or lose transparency with age.

Equally important, ALBANENE has an excellent drawing surface that takes ink or pencil beautifully and erases with ease... a high degree of transparency that makes tracing simple and produces strong sharp blueprints... extra strength to stand up under constant corrections, filing and rough handling. ALBANENE has *all* the working qualities you've always wanted—and *it will retain all these characteristics indefinitely.*

Make ALBANENE "prove it" on your own drawing board. Ask your K&E dealer or write us for an illustrated brochure and generous working sample.

EST. 1867

KEUFFEL & ESSER CO.

NEW YORK—HOBOKEN, N. J.

CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES

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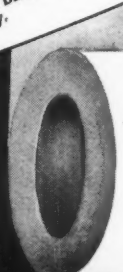


K&E *Albanene*

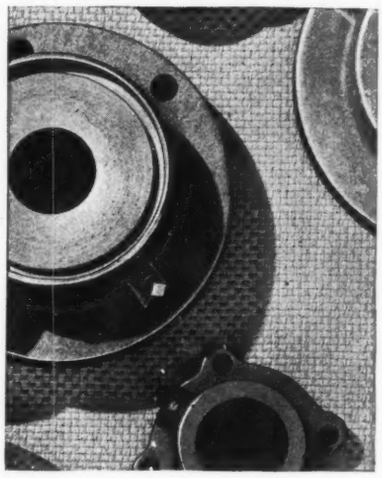
REG. U. S. PAT. OFF.

THE STABILIZED TRACING PAPER

open contacts have a tip travel of 3/64-inch. Coil wattage is 1.8. Weighing .281 pound, the relay measures 2½ x 1 5/32 x 1 25/32-inch. Other features of the relay are permanence of contact position, assurance of operation under severe vibration conditions, and operation at high altitudes at rated current.

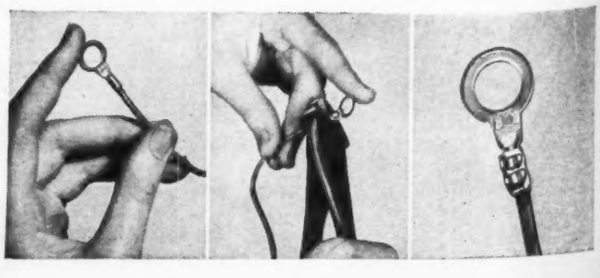
Standard Covers for Bearings

STANDARD bearing covers in a complete range of types and sizes have recently been developed by R-S Products Corp., 4530 Germantown avenue, Philadelphia. These covers form a dust and grease-tight closure to the bearing housing. Chief advantages of the units are: Low unit cost in small or large quantities, saving of costly set-ups, reduction in designing, drafting, detailing and checking time, as well as the entire elimination of the costs of patterns, fixtures, gages, etc. Conforming with standard bearing sizes, these covers should find an especially useful place in wartime design.



Cable Lug for Aircraft Use

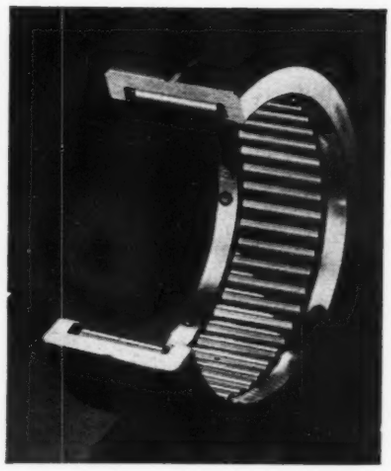
SUITABLE for aircraft, marine and commercial applications, Aircraft-Marine Products Inc., Elizabeth, N. J., has developed a new lightweight cable lug for wire sizes No. 2, No. 0 and No. 00. A collet-type clamping ring when compressed by a tightening nut applies uniform pressure from all directions, insuring electrical contact. Easy inspection of contact is permitted as wire end is always visible. When tightening nut is re-



leased, collet ring expands, permitting wire to be easily removed. Three simple parts comprise the lug which is made of copper for highest conductivity and is hot-electrotinned for corrosion resistance.

Bearings are Spot Welded

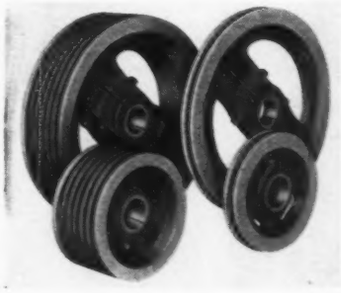
TO GIVE a sturdy, more permanent assembly and to speed up production, Bantam Bearings Corp., South Bend, Ind., has announced its improved method for installing retaining rings on its line of antifriction bearings. This is done by spot welding. A large number of small diameter rollers



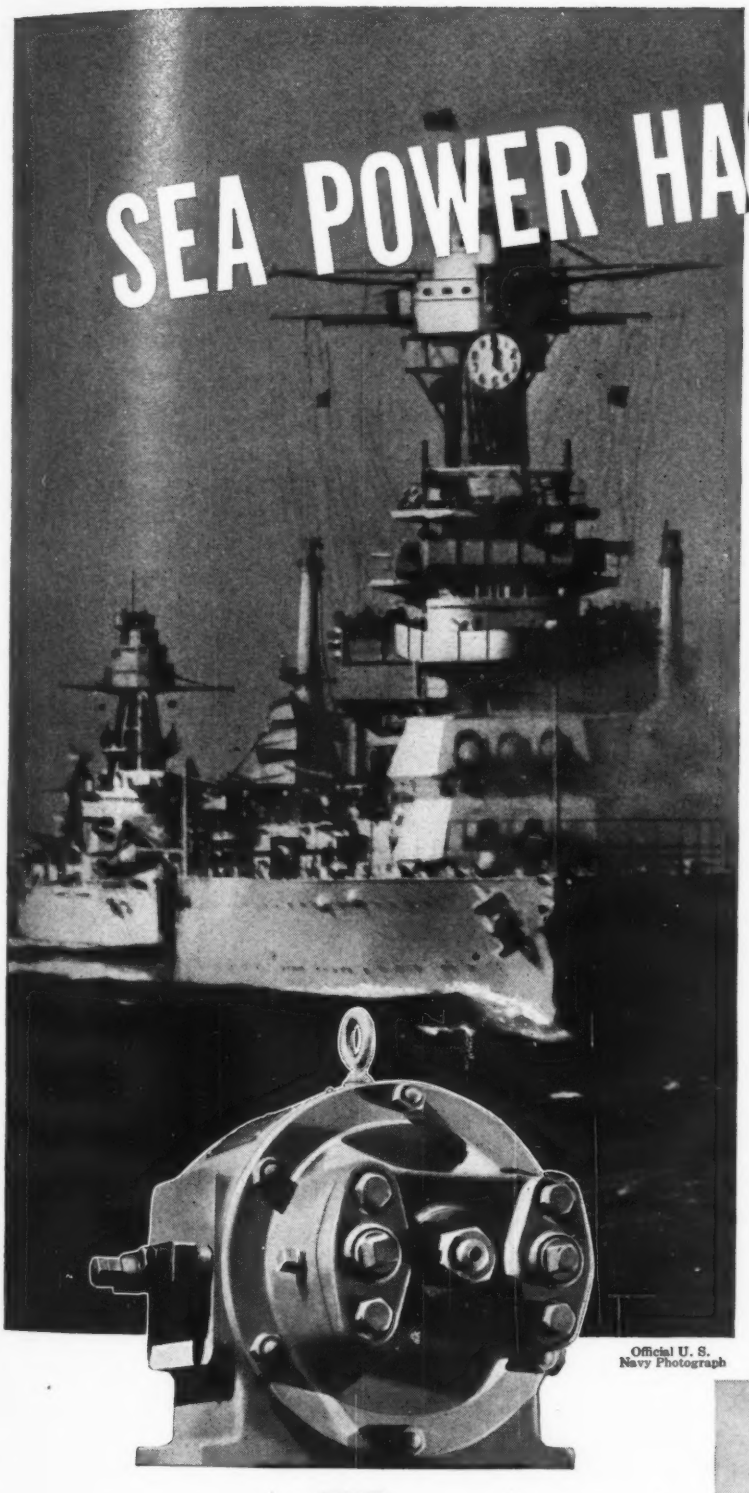
are held in place in the outer race by retaining rings and the spot-welding method gives a permanently placed band which will not snap loose under ordinary conditions. Another feature of this design is that when in service the entire load is carried to the solid outer race—none of the load, axial or thrust, being against retaining rings.

Wood Sheaves Replace Metal

AS AN alternative for metal sheaves, Dodge Mfg. Corp., Mishawaka, Ind., is offering its wooden sheaves for V-belt drives. Efficiency of these sheaves is said to be equal to that of metal



ones, except where flywheel effect is essential. Of laminated construction, the segments are of selected straight-grain kiln-dried hard maple. Wooden bushings are provided and can be firmly

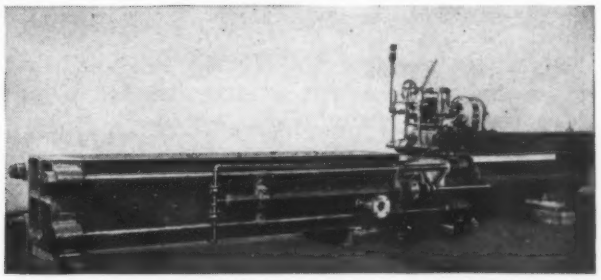


Official U. S. Navy Photograph

SEA POWER HAS NEW JOBS

Hele-Shaw Fluid Power is also making good at new jobs

Machines have to make good at new jobs today. Hele-Shaw Fluid Power is helping them. Fluid Power is oil under pressure from a Hele-Shaw Pump. It powers many kinds of hydraulically operated machines and devices. Each Hele-Shaw pump is normally designed for a certain maximum pressure. A hydraulic press, for example, that is driven by a Hele-Shaw pump at a pressure of 2000 lbs. per sq. in. today, may tomorrow have to work at 3000 pounds pressure on a war job. Various types of Hele-Shaw pump controls make the changeover a work of a few minutes. The ease of selecting the right pressure for a job is an advantage of Fluid Power Operation. There are others our fully illustrated catalog is waiting to show you. Why not send for it today?



Steeping press for the cellophane industry uses Hele-Shaw Pump with a hand-operated Hele-Shaw GAM Control. Control regulates volume and pressure independently, eliminating need for auxiliary operating valves.

THE

Hele-Shaw

Fluid Power Pump

OTHER A-E-CO PRODUCTS: TAYLOR STOKERS, MARINE DECK AUXILIARIES, LO-HED HOISTS

AMERICAN ENGINEERING COMPANY

2502 ARAMINGO AVENUE PHILADELPHIA, PA.

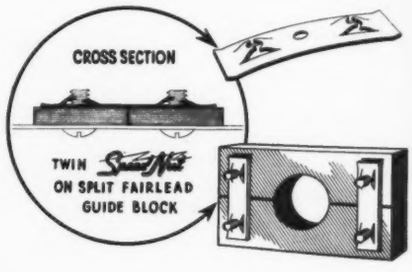
fastened to shaft. These sheaves are offered in composite groove type for "A" and "B" section belts in a full range of sizes; for "B" belts in sizes from 5.4 to 38 inches pitch diameter up to 10 grooves; and for "C" belts from 5.4 to 44 inches pitch diameter up to 12 grooves.

Transparent Insulation Tubing

HAVING an excellent resistance to brittleness down to —50 degrees Cent., a new insulation tubing has been developed by the Fibron division of Irvington Varnish & Insulator Co., Irvington, N. J. This transparent tubing has been developed to secure continued, effective insulation on aircraft flying at high altitudes. Its toughness and rubber-like qualities make it useful for a wide variety of other industrial and electrical applications. This fibronized tubing is available from size No. 24 to 1¼ inch inside diameter, and is extremely flexible. Tensile strength is 3400-3600 pounds per square inch; dielectric strength (conducted on a tubing with a wall-thickness of approximately .020-inch) is 850 volts per mil when dry and 815 volts per mil when wet. Water absorption of the tubing is .4 per cent in weight after 24 hours immersion. Allowable continuous operating temperature is 150 degrees Fahr. (66 degrees Cent.)

"Twin-Type" Speed Nuts

INTRODUCED by Tinnerman Products Inc., 2085 Fulton road, Cleveland, the "twin-type" speed nuts were designed to reduce both weight and assembly time for attaching fairlead guide blocks, and for use on many other attachments

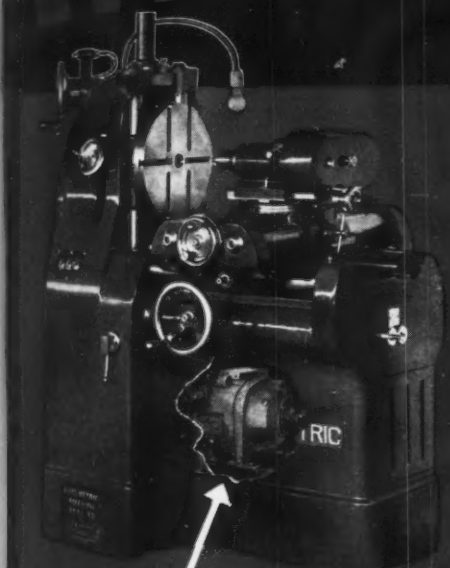


throughout a plane where fastening points are grouped in pairs. The nuts can be supplied with or without center hole for riveting and in the following sizes, indicating distance from center to center of screw holes: ½, ⅝, ¾, ⅞ and 1 inch, for either AN 515-6 and -8 or Air Corps 530-6 and -8 screws.

Welding Rod Conserves Nickel

DEVELOPED to conserve nickel, American Manganese Steel Division of The American Brake Shoe & Foundry Co., Chicago Heights, Ill., now has available a new manganese steel welding rod known as V-Mang. This electrode—an alloy

For MACHINE TOOL FEEDS...



ON THE "AUTOMETRIC" PRECISION BORING MACHINE, FOR INSTANCE,

The Graham

Performance Tells!

THE *Graham* VARIABLE SPEED DRIVE

has these* GUARANTEED ADVANTAGES over *all other Types* . . . Mechanical, Electrical or Hydraulic.

***1. UNLIMITED SPEED RANGE**
from maximum to zero. Useful working ranges up to 160 to 1 are in common use — plus reverse, if wanted, without stopping the motor.

***2. SHARP SPEED HOLDING**
under load — with FULL torque at ALL speeds.

***3. LOW PRICE** —comparable to gear boxes, but infinitely more flexible and rapid, — and more compact.— IT DOES A BIGGER WAR JOB, FOR LESS.

Write for Bulletin number 501

GRAHAM TRANSMISSIONS INC., 2706 N. Teutonia Ave., Milwaukee, Wis.

steel containing 12 to 14 per cent manganese, molybdenum and other elements—will replace the company's nickel-manganese steel electrode, except in a few exceptional cases, thus conserving this critical metal without hampering reclamation of manganese steel and other ferrous equipment parts, now so necessary. Thorough tests have shown that the new rod can be applied as readily as the one it replaces, and that it has ductility and tensile strength equal to or better than the nickel-manganese steel rod as applied. V-Mang, however, does not replace Amsco Mo-Mang, a high manganese, high carbon, molybdenum rod. The new rod is available bare and coated in ⅛, 5/32, 3/16 and ¼-inch diameters, in 18-inch lengths.

Balanced Pressure Seal

APPLICABLE to plain or antifriction bearings, the new balanced pressure seal of Stevenson Enginering Corp., 45 Willard avenue, Providence, R. I., seals fluids over a wide range of pressures at high speeds. The balanced pressure feature minimizes frictional heat and power loss, and excludes foreign matter from the bearings. The

seal is a mechanical one for rotating shafts with the initial sealing contact between the sealing ring and the hardened lapped face achieved by a light corrugated spring. Sealing against pressure is maintained by the fluid pressure itself acting upon two opposing surfaces of different areas. The full fluid pressure acts against the synthetic rubber packing, assuring a complete seal between the sealing ring and the retainer cup.

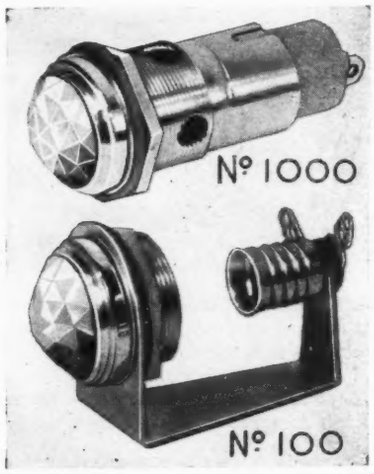
Lead-Base Bearing Metals

DEVELOPED by Magnolia Metal Co., 120 Bayway, Elizabeth, N. J., two new lead-base bearing metals are being produced as substitutes for tin-base babbitts, now so difficult to secure. One known as Pyramid Metal is suited to applications where bearings must withstand heavy sustained pressures such as are found in marine reciprocating engines, water turbines, paper mill calendar stacks and rolling mill machinery. The other, De-

fender Metal, withstands shocks without cracking and can be used in internal combustion engines, trap rock crushers and sifter machinery. The company, however, recommends its antifriction metal for steady high speeds and uniform loads such as are found in lineshafting, electric motors of 10 to 250 horsepower, pumps and general machinery.

Pilot Light Assemblies

AVAILABLE in a wide variety of styles and sizes, two of which are shown in the accompanying illustration, Gothard Mfg. Co., 1312 North Ninth street, Springfield, Ill., has developed pilot lights for use wherever this part is required. The No. 1000 faceted jewel pilot light is designed to



receive a Mazda S-6 lamp and is Underwriters' Laboratory approved. The No. 100 faceted jewel light with miniature screw socket is of horizontal mounting, open type. The jewel holder can be readily removed from the face of the panel without disturbing wiring when it becomes necessary to insert a new lamp bulb. A 1-inch hole is required for mounting the lights which can be furnished in various colors. The body is constructed from half-hard seamless brass tube.

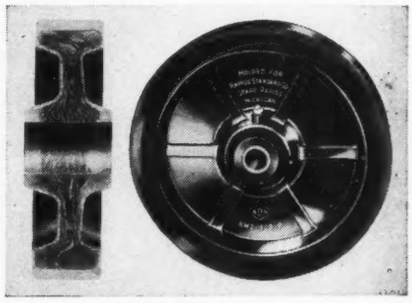
Acid-Alkali Resistant Coating

AS A substitute for galvanizing on black metal, Protective Coatings Inc., 10391 Northlawn, Detroit, has introduced its acid and alkali resistant Chempruf coatings, claimed to be immune to all acids and alkalies in any concentration and at any working temperatures. Suitable for coating or lining plating and acid tanks, fume ducts, storage and processing tanks and for all surfaces, including ceramics, the coating is offered only in black in two types, *A* and *B*. Type *A*, because of its high heat resistance, can be used in all air conditioning and acid fume ducts, while Type *B*, furnished in sheet form, replaces rubber as a lining. Two forms of Type *A* are available, one for brushing and the other replacing galvanizing, for

brush, spray or dip application. Type *B* cannot be applied by the user because of technical factors incident to bonding. The coating cannot be used in the presence of fats and oils.

All-Purpose Resinoid Wheel

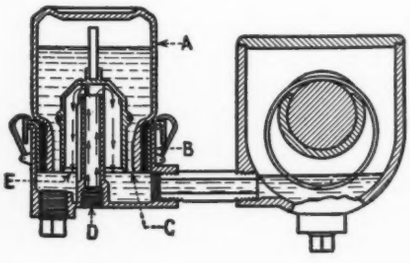
AS A RESULT of experimental work with various materials, The Rapids-Standard Co., 535 Bond avenue, Northwest, Grand Rapids, Mich., has completed and is offering its new ABK resinoid wheel which has several individualized features important to truck and caster users. They are developed to overcome floor wear and chipping, will not strike sparks, cannot be overloaded and will push easily under capacity loads, will stand



impact and are not affected by oils, greases, organic acids, dilute mineral acids and temperature changes. These resinoid wheels comprise two component parts molded under high heat and pressure into one unit. Core stock is compounded for resilience and shock-absorbing qualities to make wheel highly resistant to impact. The wheels are available in a number of different sizes for industrial truck and caster uses.

Constant Level Lubricator

ADEQUATE lubrication at all times is assured by the constant level lubricator developed by Oil-Rite Corp., 3466 South Thirteenth street, Milwaukee. Consisting of three simple parts, the lubricator has a diecast base, with an integral open-air vent which extends part way up into the



oil reservoir. When reservoir is filled and inverted into position on base, the lower edge of inverted bucket or bell determines the level which the lubricator will maintain. When level falls below this point, air from vent escapes under side of

No. 5 of a series designed to help Industry

"Standardization - - - YES Stagnation - - - NO"

IN WAR as well as peace, standardization means greater output in less time. As far as *Cone-Drive* gearing is concerned, the specification today of STANDARD *Cone-Drive* sizes wherever possible would measurably increase productive capacity and speed deliveries of this form of gearing. It would eliminate the necessity of time-consuming and wasteful designing and producing, for instance, of special hobs and cutters good only for one job.

In war as well as peace, however, standardization should never be allowed to breed stagnation. Cessation of design activity today may spell defeat in peace, if not in war.

Three years . . . two years . . . even a year, perhaps from now, new and better designs should be coming out of your experimental department, O.K.'d for production. To insure that they will, designs should be started now, and many an organization has already started them.

We will be glad to assist industry in designing gearing for tomorrow's products . . . *Cone-Drive gearing,* with its higher load capacity, greater life, greater compactness, lighter weight, and ease of lubrication.

We may be able to help you, too.

If you don't know the Cone-Drive story, send for Bulletin No. CW 41-A (for executives), or manual No. CW 41 (for design engineers).

CONE-DRIVE DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols • Detroit, U.S.A.

bell and up to top of lubricator, permitting oil to flow down until level to be maintained again seals across the base of bell. Operation is entirely automatic. The lubricators are available in four standard sizes, with capacities of 2, 4, 8 and 16 ounces.

Hydraulic Pressure Regulator

INCORPORATING an exclusive poppet-type pilot valve adaptable to all pressures from 500 pounds per square inch, a new pressure regulator has been introduced by Bendix Aviation Ltd., North Hollywood, Calif. The most outstanding feature of this type valve is that it will continue normal operation down to at least —45 degrees Fahr. It provides leakproof operation under all conditions and will not "creep" toward the cut-in or cut-out pressures. There is no appreciable shift in operating temperatures, either at a high system bleed-off or at various flow conditions. All parts of the regulator are interchangeable. The use of the poppet-type valve eliminates all lapped fits, materially speeding up production. An integral system relief valve and a check valve are incorporated with the regulator.

Metal Bonding Alloy

RECENTLY introduced by Metalloy Co., Box 3093, Terminal Annex, Los Angeles, a new metal alloy known as Galvalloy can be used to obtain a perfect soldering bond with aluminum or aluminum alloy, without use of any flux. It is also reported to bond practically all types of metals, allowing bonding of aluminum or aluminum alloys to other metals. The alloy may be used for many purposes, such as a protective coating on welded seams, or on areas where a noncorrosive coating is needed.

High-Impact Phenolic Plastic

TO REPLACE other vital materials in war production, increasing demands for heavier duty molding compounds have brought about the introduction of a new high-impact plastic of phenolic type, Durez 11934, by Durez Plastics & Chemicals Inc., North Tonawanda, N. Y. The material has a macerated fabric filler and consequently is not readily preformed. Available in black or brown, it is said to have a very good cure cycle for a material of this type. Its special impact strength makes it suitable for applications such as small pulley wheels, casters, rollers, etc.

Engineering Dept. Equipment

Tracing Cloth for Pencils

TO ENABLE the designer to produce ink-like drawings at the speed of pencil drawings, The Frederick Post Co., Hamlin and Avondale avenues, Chicago, has brought out a new pencil

tracing cloth which because of its velvety surface takes pencil perfectly. It is tough, durable and will not discolor with age. Added features are the glossy, stay-clean back and transparency, aiding to give speed to print production. Because of transparency and texture of paper, jet-black on pure white positive prints as well as sharp, major-contrast blueprints from pencil tracings can be obtained. The cloth permits the use of a 5H or harder pencil and produces the same line as with a 2H or 3H pencil on ordinary tracing cloth. Detail, however, with a hard pencil will not smudge or rub off. The paper can be erased quickly and cleanly with an art gum or soft eraser, and erasures will not show on blueprint. It is available in 20 yard rolls in widths of 30, 36 or 42 inches, or in sheet sizes cut specially to meet individual requirements.

Wooden Blueprint File Cabinets

ENGINEERING departments faced with the wartime problem of utilizing wooden units with blueprint filing cabinets built of steel, will be interested in the new line of wooden filing units now being offered by Hamilton Mfg. Co., Two Rivers, Wis. These cabinets are designed to fit

in with the present steel equipment, are styled and finished in the same olive green as standard steel units, and interlock and stack with the standard line of 2436, 3042 and 3648 steel units. Sturdy and substantial in construction, they will give adequate protection to tracings and blueprints in an engineering department.

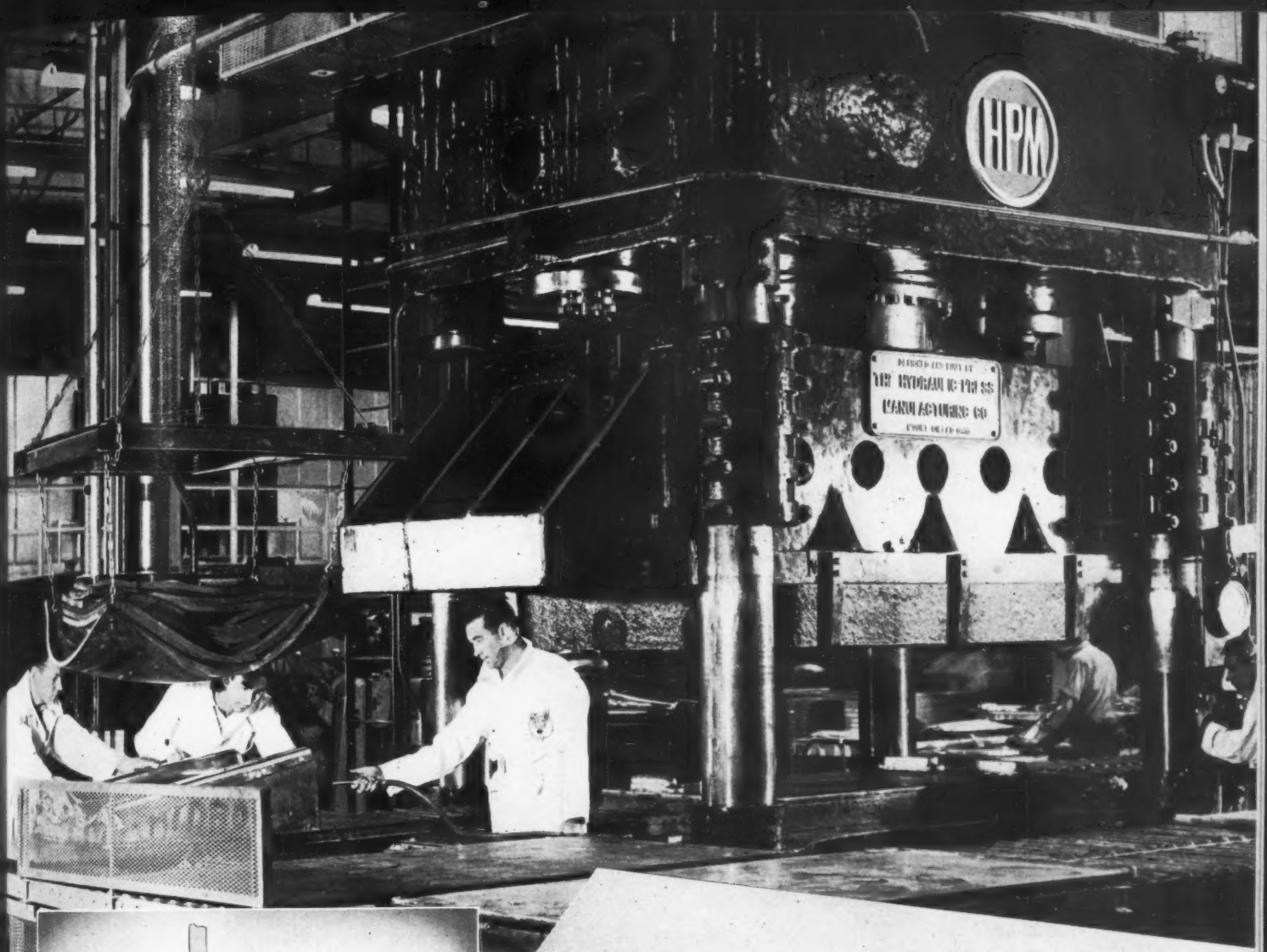
Window Guards for Protection

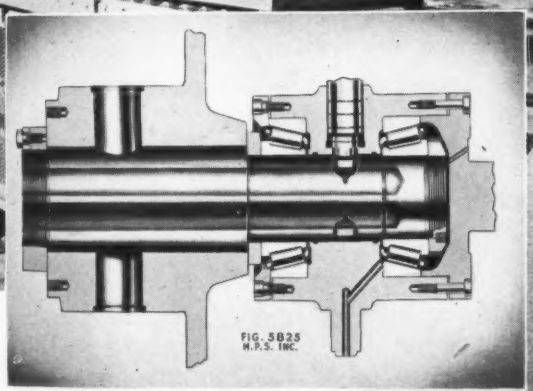
OF SPECIAL interest to engineering offices at this time are wire window guards for design departments and other applications. Introduced by Buffalo Wire Works Co. Inc., 320 Terrace, Buffalo, N. Y., the guards are custom made to individual requirements and offer complete protection because of the strength and rigidity of the material. The guards are constructed of diamond mesh or square mesh wire cloth with rod, angle-iron or channel-iron frames, and can be finished in any standard color. Meshes are supplied from ¾-inch to 8 x 8 inches, in widths of 24, 30, 36, 42 and 48 inches.

MEN *Of Machines*

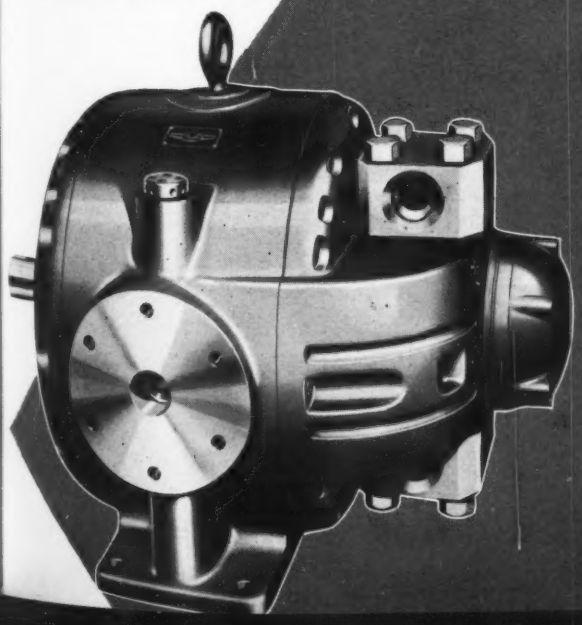
AN ENGINEER on special assignment for the A. C. Wickman Co., Ltd., Coventry, England, Paul E. Chatelain is now in charge of engineering development of various machine tools being manufactured and to be produced by Wickman Corp., Detroit. He is thoroughly familiar with the type of machines to be manufactured in this country by the company inasmuch as he had been associated with the English concern for many years, acting as sales engineer on the European continent and in other parts of the world. Mr. Chatelain was in Switzerland at the time of the fall of France, returning to England by means of a 20,000-mile journey which included a series of plane trips which brought him to Capetown, South Africa. Here he boarded a ship that finally landed him at a home port.

ANNOUNCEMENT is made by the Link-Belt Co., Chicago, of the return of Richard F. Bergmann — this time as chief engineer of the company, replacing William W. Sayers who has been appointed consulting engineer. Mr. Bergmann, a native of Logansport, Ind., was graduated from Rose Polytechnic institute in 1918 and joined the Howe Chain Co., Muskegon, Mich. The latter post he assumed af-





The HYDRO-POWER Radial Pump design incorporates tapered roller bearings for maintaining proper working clearance between central valve and rotor as shown above. Take-up for bearing wear is simple without dismantling pump or connections. This exclusive HYDRO-POWER design insures dependable service . . . long pump life. Write for Bulletin 411.



HYDRO-POWER

assures 24 hour operation of War production presses

HPM FASTRAVERSE PRESSES used to make airplanes, tanks, guns and shells rely upon the trouble-free performance of HYDRO-POWER Radial Pumps.

● HYDRO-POWER radial, piston type, pumps are available for your hydraulic systems, too. Capacities up to 185 GPM at 2500 lbs./sq. in. Investigate the many exclusive features of HYDRO-POWER pumps.

● Also included in the HYDRO-POWER line are valves, pump controls, gear pumps, power units, cylinder and ram assemblies and complete oil-hydraulic operating systems. Write . . . stating your particular hydraulic power problem. » » »

HYDRO-POWER SYSTEMS, INC.

Division of The Hydraulic Press Manufacturing Company

Mount Gilead, Ohio, U. S. A.

ter brief service as an ensign in the United States Navy during World War No. 1. Following the merger in 1924 of Howe and Link-Belt he was transferred to Chicago and was made chief engineer of the company's Caldwell plant. In 1933 he was appointed chief engineer of the organization in which position he remained until 1936 when he resigned to become chief engineer of Rayon Machinery Corp., Cleveland. Mr. Bergmann now leaves the latter company to assume his position with Link-Belt as chief engineer.

WELL-known in marine design and engineering circles, Hans Bohuslav has been appointed vice president in charge of engineering, Sterling Engine Co., Buffalo, N. Y. — this being another step in the company's all-out program in producing engines for the Navy. Before becoming associated with Sterling, Mr. Bohuslav was with Enterprise Engineering Co. as vice president in charge of engineering. Prior to this he was chief engineer. While with this company he was closely connected with a number of interesting designs such as multiple-cylinder stationary and marine diesel engines of integral block design. During the latter part of his connection with Enterprise he was associated with the development of special design of high-output, low-weight units to meet demands of national defense. His training consisting of a combination of theoretical and practical work, university courses and machine shop practice in United States and abroad, Mr. Bohuslav's experience also includes that of design and development of fuel injection equipment and special apparatus. While on the West Coast he also served as consultant for various concerns.

♦

MAJOR-GENERAL LEVIN H. CAMPBELL JR. has been nominated by President Roosevelt to become Chief of Ordnance of the United States Army. He will succeed MAJOR-GENERAL CHARLES M. WESSON, retired. General Campbell is well known in the metalworking and machine tool industries.

♦

ROE S. CLARK has been elected president of the National Metal Trades association. He is vice president and treasurer of Package Machinery Co. H. H. KERR of Boston Gear Works Inc., has been appointed vice president and GEORGE A. SEYLER,

Lunkenheimer Co., as second vice president and treasurer of the association.

♦

THOMAS A. BAGGS, who for the past sixteen months has been an industrial specialist with the Office of Production Management and War Production board, is now chief of the truck section of the automotive branch of W.P.B.

♦

MARVIN LEE, formerly chief engineer of Burndy Engineering Co., New York, has been named acting general manager to fill the vacancy caused by the absence of BERN DIBNER, vice president and general manager. Mr. Dibner has joined the United States Air Corps with the rank of Captain.

♦

IRA A. TERRY has been appointed general assistant to H. A. WINNE, vice president in charge of design engineering, apparatus department, General Electric Co. WALTER C. HECKMAN of the Turbine Engineering department has succeeded Mr. Terry in the works manager's office as assistant to J. D. HARNDEN.

♦

EMIL ERDELSKY has accepted a position with Crocker-Wheeler Mfg. Co., Ampere, N. J., which will involve both design and application of electrical rotating machinery for many purposes augmented by the war effort.

♦

J. G. SHRYOCK has received an honorary degree of Doctor of Science in Engineering from the Pennsylvania Military college, Chester, Pa. Mr. Shryock is president and chief engineer of Belmont Iron Works, Philadelphia.

♦

CLYDE R. PATON recently resigned as chief engineer of the Packard Motor Car Co., and joined the engineering staff of Allison division of General Motors Corp., Indianapolis.

♦

ALFRED SONTAG, formerly chief engineer and sales manager of Riehle Testing Machine division, American Machine & Metals Inc., has joined the testing machine department of Baldwin Southwark division, Baldwin Locomotive Works.

♦

J. M. BIRKENSTOCK was recently elected president of the National Association of Fan Manufacturers; EDGAR F. WENDT, vice president and L. O. MONROE, secretary and treasurer.

♦

WILLIAM L. ABBOTT, past-president of the American Society of Mechanical Engineers, and retired chief operating engineer of Commonwealth Edison Co., was recently the recipient of the Washington award "for advancing the standards of the engineering profession; for services to higher education; for aiding combustion research."

♦

CLAY C. CRAWFORD, who has been engaged in aerodynamic research, has been appointed assistant to the chief, Bureau of Priorities Division of Industry Operations, War Production Board.

What's New at 35,000 RPM?

Frankly, we don't know. Maybe you can tell us.

Perhaps you have a product in mind for after the war, where high speed rotation could bring about new economy of production in some industrial or process application . . . providing you had a practical, dependable method of lubricating spindle bearings.

Onsrud has definitely solved the problem of lubricating a shaft at hitherto prohibitive rotative speeds. For over two years Onsrud-built spindles with Metered Mist construction have been doing day after day jobs at speeds ranging from 5,400 RPM to 75,000 RPM. Millions of machine hours of operation have proved the soundness of Metered Mist . . . a centrifugal force feed system of lubrication never before presented to the engineering world. This system will be available for other applications.

Now we'd like to add our experience to yours, in working for new results in your field. We are not looking for new machines to build. After the war, however, we would like to sell our high cycle and air turbine motors, or just our spindles, for use in *your* machines.

In the meantime, we'd like to give you the facts about Metered Mist in the form of a report that we've prepared. On this basis, your inquiry is invited.

ONSRUD MACHINE WORKS, Inc.

2220 N. Springfield Avenue • Chicago, Illinois, U. S. A.

Onsrud

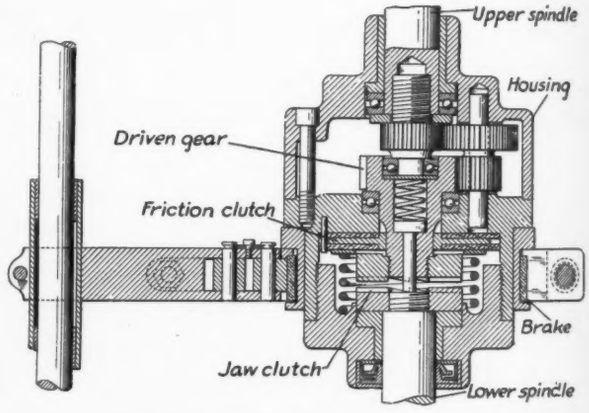
PIONEERS AND BUILDERS
OF AIR TURBINE AND HIGH CYCLE
TOOLS AND MACHINES

Noteworthy PATENTS

Screw Tightener Has Two Speeds

TIGHTENING of screwed fittings requires a rapid drive during unresisted initial rotation, a slower high-torque drive during actual tightening and a stoppage of rotation when the predetermined final torque is reached. These requirements are met in a two-speed torque-controlled drive covered by a patent assigned to Detroit Power Screwdriver Co.

An upper driving spindle shown in the figure drives a lower, work-engaging spindle through



Spring-controlled friction clutch and brake determine torques at which speeds change

transmission gears and two clutches. When the lower spindle is off the work the jaw clutch is held disengaged by a spring. When pressure on the work compresses this spring the clutch is engaged, coupling the lower spindle to a driven gear which is connected to the upper spindle through a double reduction reverted train of gears. A spring-controlled friction clutch connects the driven gear with the housing.

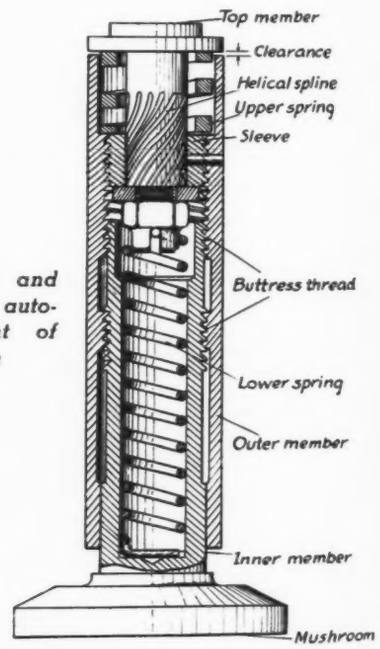
Initially the gears are locked to the housing through the friction clutch, and the upper spindle drives the lower with a one to one speed ratio by rotating the whole assembly including the housing. As the screw begins to tighten, the friction clutch slips at a predetermined torque and the housing tends to rotate in the opposite direction due to the speed difference between upper and lower spindles. Backward motion, however, is pre-

vented by a spring-controlled one-way brake which engages the housing. Housing being stationary, the lower spindle is now driven through the reduction gears while the friction clutch slips. The speed ratio is of the order of four to one, the correspondingly increased torque serving to complete the tightening. When the predetermined final torque is attained the brake slips, the housing rotates backward, and no further rotation of the lower spindle occurs. Raising the housing allows the jaw clutch to disengage, and the release of torque lets the friction clutch lock the driven gear to the housing in readiness for the next cycle.

Controls Cam Mechanism Clearance

SLACKNESS in cam mechanisms is automatically taken up while at the same time predetermined clearance is maintained in a patent assigned to Thompson Products Inc. The device is designed to replace existing tappet followers which have merely a fixed length adjustable by hand.

Inner member has a mushroom end making contact with the cam profile, and is threaded to the outer member which slides in the tappet guide bearing. Top member has a helical spline engaging a sleeve fixed to the outer member, and a threaded extension carrying a washer and slotted nut. Top member is held extended by the upper helical spring which exerts an axial force. Inner member is held extended by the lower helical spring, which is assembled so as to exert a torque tending to unscrew the outer and inner members. The friction and thread inclination, however, are such that no relative movement occurs under static conditions.



Impacts on lift and return action aid automatic adjustment of tappet length

When the cam exerts pressure on the mushroom, the outer member and top member move towards each other, the splined connection causing

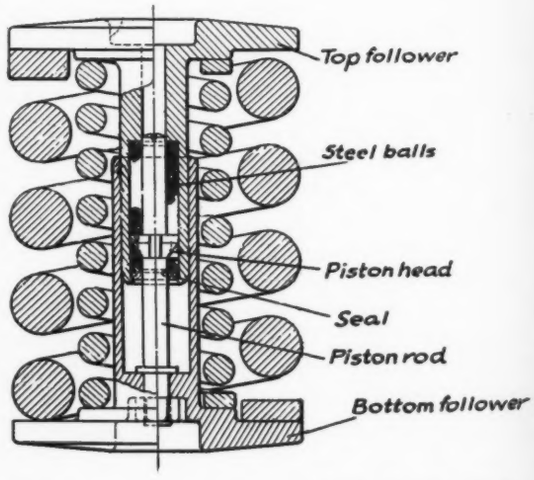
slight rotation. Relative movement ceases when the predetermined clearance is absorbed; the clearance is that normally provided in such mechanisms and is equal to the height of the ramp on the cam profile if such is provided. The impact and vibration are sufficient to cause the inner and outer members to screw together slightly, shortening the linkage a very small amount.

At the end of the return the top member separates from the inner member and the unscrewing action exerts a torsional impact on the lower spring. As the inner and outer members are no longer held together but are subject to an extending action due to the lower spring, the torsional impact is able to extend the members if there is excess clearance. Threads under this condition bear on the flat sides of the buttress, are subject to less friction and move more easily.

Mass of Balls Replaces Fluid

SHOCK absorbers using a fluid medium require close fitting to reduce leakage, while the performance is subject to variation with changing fluid viscosity due to temperature effects. Using a large number of small, hardened steel balls immersed in heavy lubricating oil or grease, a patent assigned to American Steel Foundries overcomes these objections.

For practical purposes the mass of balls behaves like a heavy fluid, following the laws of hydraulics, but of course will not leak through openings smaller than the ball diameter. A typical application, shown in the figure, represents a spring mounting. Space above and below the piston, which is secured to the bottom follower, is completely filled with the small balls which the designer terms a "ball-draulic" medium. Slots in the piston head permit the transfer of balls from one side to the other. Force required to transfer



Spring mounting uses "ball-draulic" medium for shock absorption

(*Concluded on Page* 134)

Victory begins with

RIGHT EQUIPMENT

For today's wartime tanks, planes, guns, ships and other fighting needs... Unitcastings are being produced with all-out speed that's geared to automatic accuracy... in America's most modern electric steel foundry! In all production operations at Unitcast ... Quality and Uniformity are jealously guarded. It pays to use Unitcastings—*they're better* for the urgent war needs of today... or for an increasing range of applications in peacetime tomorrow.

Unitcast Corporation, Toledo, Ohio.

UNITCAST
CORPORATION

ALLOY AND CARBON ELECTRIC STEEL
CASTINGS

(*Concluded from Page* 128)

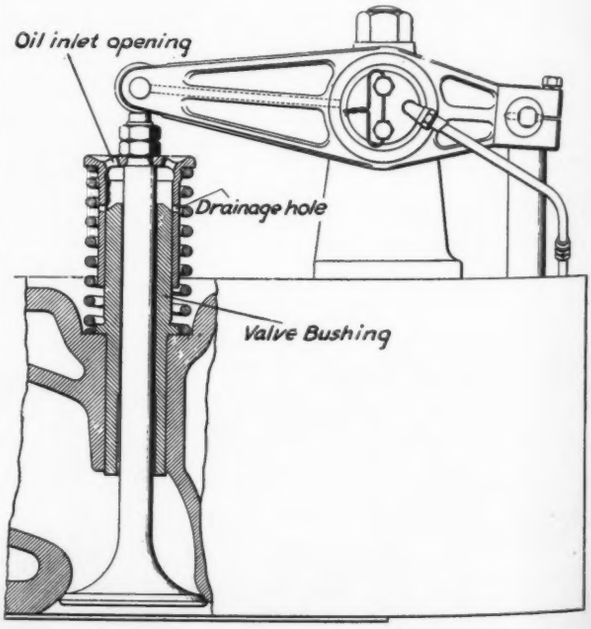
the balls depends on the velocity of piston movement relative to the top follower. Only slight resistance is offered to slow motion.

Because of the large clearance possible, it is claimed that internal machining of the cylinder is unnecessary, a good cast surface being sufficiently accurate.

Prevents Sticking Valves

STICKING valves on internal combustion engines, due to carbonizing of the oil used to lubricate the stem, may be a serious problem when power capacity and heat dissipation through the valve are high. A stem fitting tightly enough to prevent excessive leakage needs adequate lubrication. Sufficient supply of lubricant to meet all conditions of speed and load may be too much for some conditions, and the excess oil becomes carbonized at the high temperature prevailing in the guide. Guiding the valve by means of a well-lubricated sleeve outside the stem itself, removed from the highest temperature region, is the essence of a patent assigned to the Baldwin Locomotive Works.

Large clearance is provided in the valve bushing except for a short distance at the lower end. The upper outside surface of the bushing furnishes the bearing for a sleeve rigidly secured to the end of the valve stem. Oil supplied through the openings shown at the top of the sleeve mostly flows down the interior surface of the sleeve, lubricating the guide. Surplus lubricant drains through the holes provided in the side, when the valve is closed, the conical shape of the bushing end assisting in the deflection of excess oil away from the stem.



Excess oil flows away from stem, lubricates outside guide bearing

POWER...and still more POWER for the Navy

These reduction gear units—important links between motor and propeller in naval vessels—are made of Cast Steel.

Steel Castings are used for this purpose for a very sound reason—they are the quickest and least costly way of securing the strength, the stamina, the precision and the wearing qualities needed for this vital job.

It is significant that the maker of these parts has just been asked to quadruple his output!

There are no adequate substitutes for Steel Castings in thousands of applications—for both armament and peacetime goods—no other materials that do the work quite so well, or that can be turned out so quickly at such low cost.

Should you find it difficult to get steel castings when you need them, it is because they have so many important jobs to do, and are in such great demand.

But you'll find your steel foundryman a resourceful man, anxious to help solve your problem. Or you may write to Steel Founders' Society, 920 Midland Building, Cleveland, Ohio.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

War Needs Speeded by Resistance Welding

(*Concluded from Page* 64)

plication requiring high production and close tolerances involves a combination of hot riveting with spot welding and is illustrated in *Fig.* 4. This is a part of a machine gun magazine entirely fabricated from sheet steel stampings. In this case the spot-welding machine is utilized for performing the hot riveting operations.

Spot Weld Aircraft Assembly

As an indication of uses in aircraft a subassembly is shown in *Fig.* 5. Spot welding fastens an outside flat sheet to an inner reinforcing formed sheet. This particular unit is an access door which is bolted to the main structure by mounting holes. All welded areas had been cleaned prior to welding to remove aluminum oxide. In this particular assembly the oxide was removed with a rotating wire brush. Wire brushing, steel wool and chemical dips and etches are the prevailing methods for cleaning this type of alloy. The assembly shown was welded at a machine speed of approximately eighty spots per minute.

Seemingly insignificant is the application in *Fig.* 6. Spot welding of the tin-coated copper braid, however, is not an easy job but is entirely feasible for production. This job was developed to conserve tin by the elimination of soldering and because severe breakage was encountered on the flexible braids, resulting from the run back of the solder.

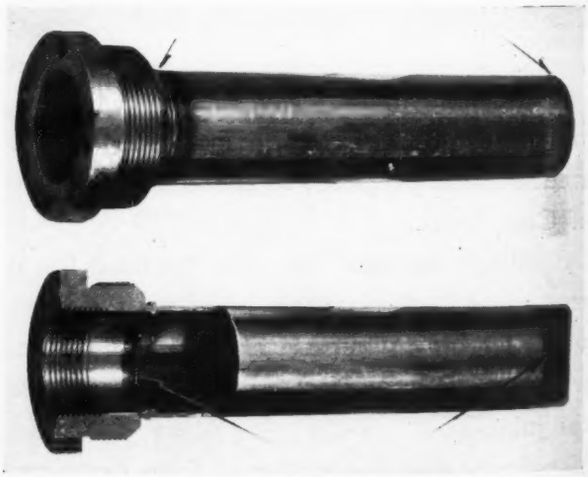
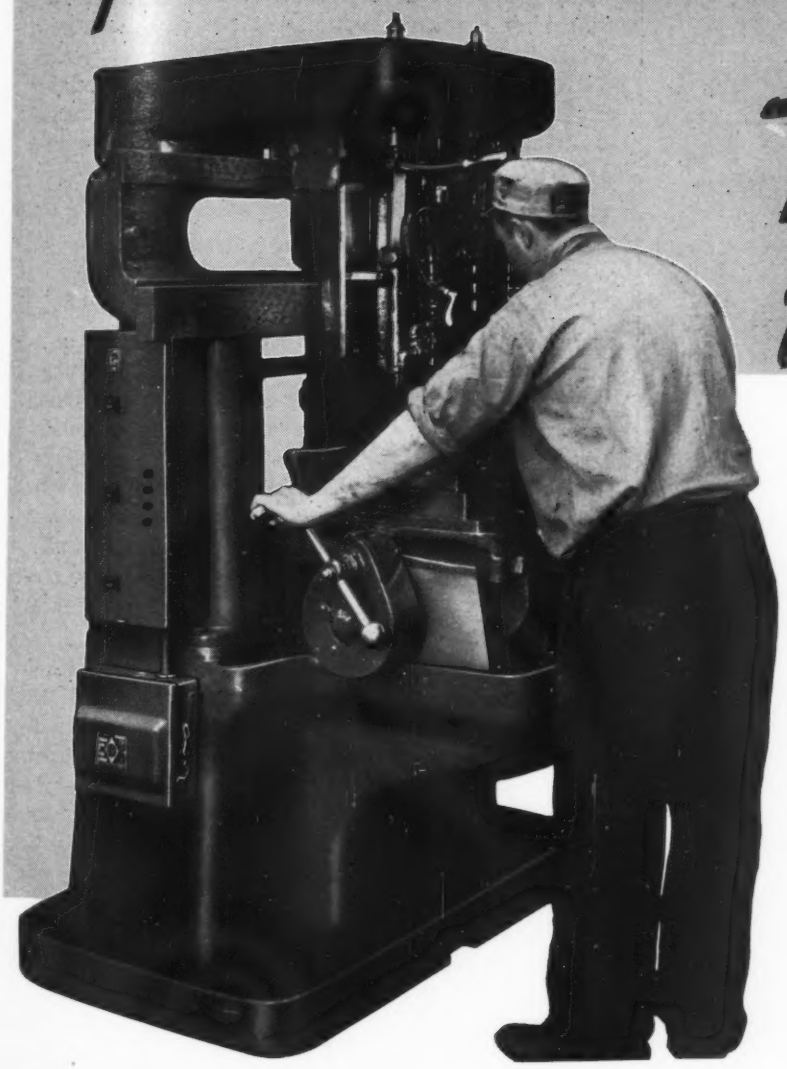


Fig. 11—Bomb burster casing utilizes ring-projection welding, eliminating expensive machining operations

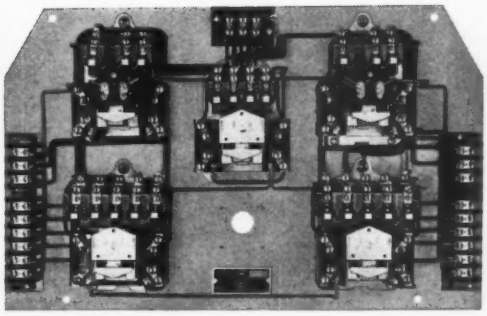
Welding of armor plate is usually considered difficult. *Fig.* 7 shows test specimens of spot welds on this material. The tensile test indicates clearly that the failure is beyond the weld region.

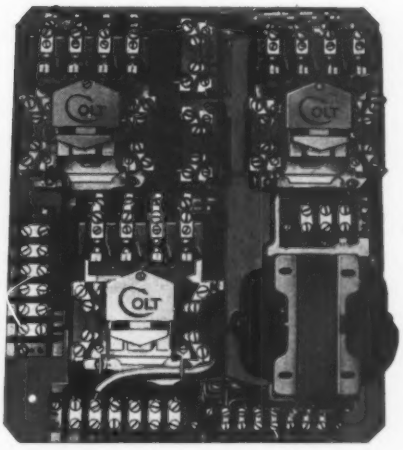
In heat economizers and heat exchangers for

Special COLT CONTROL PANELS *Tailored for the Job*



Special Colt Control Panels — designed to meet exact requirements — are being specified by builders as well as users of machine tools. Constructed by assembling and interconnecting standard Colt Control units, the panels are sturdily built for long-life performance. Compactly arranged . . . readily accessible . . . identified control wiring. Tell us your specifications and we'll be glad to show you how a Colt Control Panel can be "tailored" for *your* application.





Typical Examples of Special Colt Control Panels

COLT'S PATENT FIRE ARMS MFG. CO. - Electrical Division - HARTFORD, CONN.

all types of military equipment from bombers to destroyers, resistance welding has permitted the substitution of ordinary steel for stainless steel and aluminum. In other cases, the amount of the strategic material in the assembly has been considerably reduced through the use of a resistance welded design. Formed entirely from two stainless steel stampings is the aircraft engine exhaust stack in *Fig.* 8. The flanged edges are seam welded and the junction between the two ports is secured by spot welding.

Ring Projection is Useful

Ring projection welding has many useful applications such as shown in *Figs.* 9 and 10. *Fig.* 9 illustrates the general method for installing bungs. A similar process is employed for spuds in medium pressure vessels. In fact most of the porcelain-lined units must have pipe connection reinforcements welded in this manner to permit the flow of porcelain enamel over the welded region and completely seal the metal. Also, in this manner, small lugs are welded to relatively thin gage material and are drilled and reamed after welding to support bushings for small bearings.

The insert is welded to 18-gage sheet steel and has .14-square-inch weld area. A current of 50,000 secondary amperes is required for the weld with 2500 pounds pressure. Production is 750 per hour. An idea of the savings that can be effected by ring-projection welding for the fabrication of unusual parts is indicated in *Fig.* 10. It would be difficult to duplicate this small assembly by any other manufacturing method at anywhere near the same cost. The drawing of this part shows the method used to reduce the projection area. In this way the welding current used and the resulting strength of the joint are easily controlled. Round stock is welded to flat stock with a weld area of .1-square-inch, requiring 20,200 secondary amperes and a pressure of 625 pounds.

Obviates Extensive Machining

Another utilization of projection welding is seen in *Fig.* 11. Previously, bomb burster casings were expensive to produce and required a tremendous amount of machine shop facilities to produce the quantities desired. This design, however, involves only a simple sheet metal stamping for the top cap, a piece of seamless steel tubing or resistance welded tubing for the body and a relatively simple screw machine part for the mounting cap. Of particular importance is the small sheet metal cap. To eliminate an expensive machining operation it is desirable to weld the cap with minimum distortion and flash from the weld itself. To accomplish this, a weld of short timing is required which in turn requires considerably more power to weld the small cap to the top of the tube than is required to weld the large screw machine part to the bottom of the tube.

Business and Sales Briefs

PRIOR to his present appointment as manager of the motor division, Industrial department, General Electric Co., Schenectady, N. Y., W. H. Henry was manager of sales of this division. Former manager of this division, C. F. Pittman, is now assistant to the manager of the industrial department.

♦

Robert E. Mason, who previously was associated with International Nickel Co. and Peter A. Frasse & Co., has joined the sales department of Tube Reducing Corp., Wallington, N. J.

♦

Formerly connected with Edgar T. Ward Co., F. B. Davis has been made Buffalo district manager for Copperweld Steel Co., Warren, O., to manage sales of Aristoloy alloy steels.

♦

In his newly appointed position as manager of Allis-Chalmers general sales organization, William C. Johnson will direct the sales of 1600 different products and operations of 60 district offices. Mr. Johnson was formerly sales manager of the crushing and cement division.

♦

Banquets were held recently at Bridgeport and New York to celebrate the seventy-fifth anniversary of Handy & Harman. The banquets were attended by company officials and its 600 employes. A booklet was also released giving interesting facts about the company's history, facilities, and war work now in progress.

♦

According to a recent announcement Herschel E. Post has been made sales manager of the industrial finishes section of Pittsburgh Plate Glass Co., with headquarters in Pittsburgh. He formerly was manager of the company's Houston, Tex., paint factory.

♦

Succeeding H. H. Arbuthnot, who has been transferred to the Pittsburgh sales office of Allegheny Ludlum Steeel Corp., as assistant general sales manager, J. D. McKnight will act as manager of the Detroit district sales office of the company. Formerly assistant manager at Detroit, Mr. McKnight has been associated with Allegheny Ludlum for six years.

♦

Marking his fiftieth anniversary of service with Phelps Dodge Corp., New York, Martin Crego, manager of sales, was presented with an inscribed silver service medal which was presented at a testimonial dinner.

♦

Gerald F. Coons has been made manager of sales of the New Orleans office of National Tube Co., Pittsburgh, replacing Harry L. Bialock who has become associated with Tubular Products Inc., Gary, Ind.—both companies being subsidiaries of United States Steel Corp.

♦

Establishment of the Frayco Electric Motors Co. has been announced by the Fray Machine Tool Co., Glendale, Calif. The new company has been formed

by the latter to build the complete line of motors from 1/3 horsepower to 7¼ horsepower previously built by the Fray Machine Tool Co. for its exclusive use. Frayco company will specialize in the production of motors with special end bells, for manufacturers of machine tools and other equipment. The new plant will be located at 1709 Standard avenue, Glendale, Calif., under the management of O. W. Weyman.

♦

Appointment has been made of V. A. Jevon and A. J. Hazlett as assistant general managers of sales, Jones & Laughlin Steel Corp., Pittsburgh. Mr. Jevon had been assistant to vice president in charge of sales since October, 1938, while Mr. Hazlett had been manager of the strip-sheet sales department.

♦

Opening of a warehouse at 210 East Thirty-fourth street, New York city, by John F. Diehl to carry a substantial stock of all types and sizes of toggle clamps has been announced by Detroit Stamping Co., Detroit, manufacturers of clamps and pressed metal products.

♦

Pioneer Engineering & Mfg. Co., Detroit, has appointed Paul Hacker as pump engineer in charge of sales. Mr. Hacker for the past 27 years has been associated with Packard Motor Car Co.

♦

Recently the American Rolling Mill Co.'s Ashland division tied down its mill whistles in celebrating the fact that "521 production records were broken since Pearl Harbor".

♦

Nearing completion is a program of expansion under way by Keystone Carbon Co., St. Marys, Pa., which includes plant and production facilities.

♦

Plans to expand its plant, through both buildings and equipment, to the extent that output will be increased within the next 18 months to six times the present quota, are being made by Fairbanks, Morse & Co.

♦

Change of name of the former Plastikon Co., extruders of all types of thermoplastics, has been made to National Plastic Products Co. The company will be located at 100 McPhail street, Baltimore.

♦

Recently the Plaskon Co. Inc., Toledo, O., formerly dedicated their new laboratories for research and engineering.

♦

As direct aid to the war effort, Osborn Mfg. Co., Cleveland, has expanded its brush engineering field service which will co-operate with war plants to obtain efficiency and speed from power brushing in production of warships, tanks, planes, guns, munitions and similar equipment for war. The men appointed to this field service staff are: Page A. Mead will be located in Delmar, N. Y., serving in eastern portion of New York state; Paul A. Malling will cover New Jersey and will be located in Fairlawn; William F. Short will be located in Hamburg, N. Y., serving Buffalo and western New York state; and Max Sherwood, Gilbert B. Pecsok and Ralph B. Jones will work out of the company's Chicago, New York city and Cleveland offices, respectively.

NEW MACHINES—

And the Companies Behind Them

(For illustrations of other outstanding machinery, see Pages 82-83)

Air Conditioning

Cold room conditioner, Niagara Blower Co., New York.

Ammunition

*Shell turning lathe, Norwood Engineering Co., Florence, Mass.

Dairy

Vacuum spray dehydrator, Mojonnier Bros. Co., Chicago.

Engines

*Multifuel injection engine, Waukesha Motor Co., Waukesha, Wis.

Excavating

Convertible shovel dragline crane, Link-Belt Co., Chicago.

Finishing

Washing machine, Alvey Ferguson Co., Cincinnati.
Automatic blast cleaning machine, Pangborn Corp., Hagerstown, Md.

Forging

*Self-contained forging press, The Hydraulic Press Mfg. Co., Mt. Gilead, Ohio.

Heat Treating

Laboratory furnaces, K. H. Huppert Co., Chicago.

*Illustrated in pictorial spread, Pages 82-83.

Industrial

Heavy-duty cleaner, Breuer Electric Mfg. Co., Chicago.

Materials Handling

Hydraulic jacks, Watson-Stillman Co., Roselle, N. J.
Cranes, Lima Locomotive Works Inc., Lima, Ohio.
*Crane, The Osgood Co., Marion, Ohio.
*Shipyard revolvers, American Hoist & Derrick Co., St. Paul, Minn.

Metalworking

High-speed friction saws, Kling Bros. Engineering Works, Chicago.
Hydraulic metal stretching press, Hydraulic Press Mfg. Co., Mt. Gilead, Ohio.
Metal turnings crusher, The Jeffrey Mfg. Co., Columbus, Ohio.
Thread milling machine, Waltham Machine Works, Waltham, Mass.
Honing and lapping machine, Automotive Maintenance Machinery Co., North Chicago, Ill.
Hydraulic extruding press, Beatty Machine & Mfg. Co., Hammond, Ind.
Machine for shaping metal strips, Lockformer Co., Chicago.
Oil hydraulic press, Denison Engineering Co., Columbus, Ohio.
*Electric shear, Van Dorn Electric Tool Co., Towson, Md.
*Metal forming machine, Southern Engineering Co. Inc., Los Angeles.
*Radial tapping machine, Bakewell Mfg. Co., Los Angeles.

Mining

Portable scraper-hauler, Sullivan Machinery Co., Michigan City, Ind.
Switching locomotive, Atlas Car & Mfg. Co., Cleveland.

Office

Package tying machine such as currency, statements, etc., B. H. Bunn Co., Chicago.

(Continued on Page 146)

Packaging

Automatic can sealer, Minnesota Mining & Mfg. Co., St. Paul, Minn.

Automatic labeler, Economic Machinery Co., Worcester, Mass.

Bar wrapping machine, Package Machinery Co., Springfield, Mass.

Paper

Machine for gluing paper boxes, luggage, etc., Minco Products Corp., New York.

Refinery

High-pressure portable compressor, Tallman Mfg. Co., Shelbyville, Ill.

Rubber

Twin-arc weather-ometer, Atlas Electric Devices Co., Chicago.

Centrifugal pump, Tri Clover Machine Co., Kenosha, Wis.

Testing

Abrasive vacuum pick-up, Taber Instrument Corp., North Tonawanda, N. Y.

Gage for bevel gears, Herkimer Tool & Model Works, Herkimer, N. Y.

Textile

Pocket and edge folding machine, Koenig Steam Iron Mfg. Co., Philadelphia.

Overseamer, Mutual Machine Co., New York.

Fiber cutter, F. J. Stokes Machine Co., Philadelphia.

Cloth opening and closing machine, Birch Bros. Inc., Somerville, Mass.

Doubling and tacking machine, Dinsmore Mfg. Co., Salem, Mass.

Pusher mill for heavy felts, Riggs & Lombard, Lowell, Mass.

Welding

*Seam welders, Progressive Welder Co., Detroit.

Woodworking

Single-planer or cabinet surfacer, Buss Machine Works, Holland, Mich.

Vertical boring machine, B. M. Root Co., York, Pa.

Meetings and Expositions

July 22-23—

American Society of Civil Engineers. Summer convention to be held at The University of Minnesota, Minneapolis. George T. Seabury, 33 West Thirty-ninth street, New York, is secretary.

August 23-26—

National Association of Power Engineers Inc. Annual meeting to be held at Roosevelt hotel, New Orleans. George W. Miller, 498 Winspear, Buffalo, is secretary.

September 9-11—

American Institute of Electrical Engineers. Pacific coast convention to be held at Vancouver, B. C. H. H. Henline, 33 West Thirty-ninth street, New York, is secretary.

September 11-17—

American Chemical Society. Semiannual meeting to be held at Statler Hotel, Buffalo. Dr. Charles L. Parsons, 1155 Sixteenth street, Washington, D. C., is secretary.

September 16-18—

National Petroleum association. Annual meeting to be held at The Traymore hotel, Atlantic City. Mrs. M. C. Mallon, 930 Munsey building, Washington, D. C., is secretary.

September 22-24—

Association of Iron and Steel Engineers. Annual meeting to be held in Pittsburgh. J. L. Miller, Empire building, Pittsburgh, is secretary.